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THE RÖNTGEN RAYS IN MEDICAL WORK

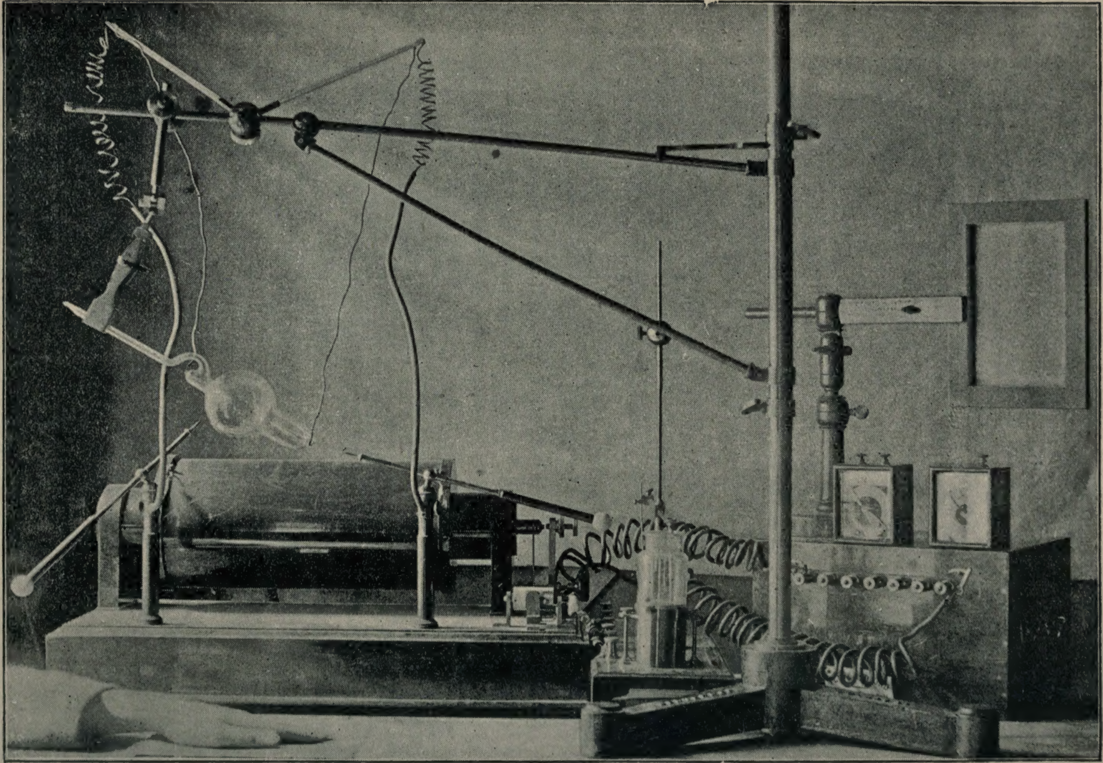

Fig. 1.—Complete Apparatus for Röntgen Ray Work, consisting of Secondary Battery, Voltmeter, Ammeter

THE RÖNTGEN RAYS IN MEDICAL WORK

BY

DAVID WALSH, M.D. EDIN.
PHYSICIAN WESTERN SKIN HOSPITAL, LONDON, W.
LATE HON. SEC. RÖNTGEN SOCIETY, LONDON

PART I.—***APPARATUS AND METHODS***

RE-WRITTEN BY

LEWIS JONES, M.D. CANTAB., F.R.C.P.,
MEDICAL OFFICER IN CHARGE OF THE ELECTRICAL DEPARTMENT OF ST. BARTHOLOMEW'S HOSPITAL

PART II.—***MEDICAL AND SURGICAL***

(BROUGHT UP TO DATE WITH AN APPENDIX)

φάος κάλλιστον τῶν προτέρων

THIRD EDITION

LONDON
BAILLIÈRE, TINDALL AND COX
8, HENRIETTA STREET, STRAND
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PREFACE TO THIRD EDITION

In this edition the author has had the invaluable help of Dr. Lewis Jones, who has re-written Part I. The purely medical and surgical aspects of the subject have been brought up to date by an appendix added to Part II. of the second edition. Should this little work attain the dignity of another edition, it is hoped that the whole of the illustrations will be raised to the high standard of the best modern work.

D. W.

70A, GROSVENOR STREET,
LONDON, W.

PREFACE TO FIRST EDITION

SINCE the famous discovery announced by Professor Röntgen at the end of the year 1895, a new science has sprung into being. This branch of knowledge, although still in its early and undeveloped stages, has found a special application in medical work.

In this little volume the aim has been to deal with the present practical scope of the Röntgen rays so far as physicians and surgeons are concerned. An attempt has been made to treat the matter systematically, and to point out limitations and possibilities, as well as to record actual achievements. In this endeavour the author has received invaluable help from Mr. J. E. Greenhill, who has also kindly written an introductory part dealing with electrical methods and apparatus. He is also indebted to Messrs. Barwell, Mackenzie Davidson, Lynn Thomas, Professor Waymouth Reid, and many others, for the use of Röntgen photographs and of notes of cases. Where all is new, it is by no means easy to decide what is likely to prove ultimately true; but the task of selection has been guided by a constant reference to the everyday conditions of medical practice.

D. W.

September 1, 1897.

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THE RÖNTGEN RAYS IN MEDICAL WORK

PART I

ELECTRICAL APPARATUS AND METHODS

BY LEWIS JONES, M.D.

INTRODUCTORY

THE essentials for the production of Röntgen or x rays are a vacuum tube of high exhaustion and an exciting electrical discharge of high potential. Among the means adopted for obtaining the necessary electrical pressure may be enumerated the static machine, the induction coil, the step-up transformer (high voltage), and the high frequency or Tesla coil. Of these the first only is a prime generator, the others being devices for transforming and converting low electrical potentials into potentials high enough to excite the x-ray vacuum tube. Consequently, with all these instruments, except the static machine, a source of electricity is required whereby to feed the apparatus.

The static machine, therefore, starts apparently with a great advantage in that it is capable of generating directly, and in one operation, a current suitable for the excitation of x-ray tubes; but this advantage is discounted partly by the fact that mechanical power is consumed in driving the static machine, and that, given the mechanical power, one may use it more advantageously under certain circumstances in driving a dynamo, and so generating a current of low pressure which may afterwards be transformed to high pressure by an induction coil.

Hand-labour may be used for the static machine, and will often serve very well for screen work or for short photographic exposures. When exposures of several minutes are needed, however, or when the apparatus is likely to be in frequent use, the labour of turning the machine by hand soon becomes troublesome, and mechanical power is required.

When once power is installed, whether electrical, water-motor, or gas-engine, the question of the relative advantages of static machine or of dynamo and induction coil will need to be carefully considered, and the final choice guided mainly by the nature of the work to be done.

In actual practice most *x*-ray work is done with induction coils capable of giving a 10 or 12 inch spark, and the coil is driven by a battery of accumulator cells, of which eight to ten or twelve are used. This may be regarded as the typical apparatus, and it will long continue to hold that position; for it is capable of transportation to the bedside, it is not directly dependent upon the presence of an electric lighting main, and it gives first-class results.

Many of the modifications introduced into recent *x*-ray practice have the drawback that, while they improve the quality or the rapidity of the work which can be done, they nevertheless render the apparatus less easy of transportation, or they can be used only in places where electric light mains can be tapped, and therefore they lack some of the universality of application which is possessed by the outfit composed simply of coil and battery.

Still, for permanent installations and for work of the highest quality, the introduction of devices for making use of the electric light mains represents a real advance.

In dealing with the subject of apparatus for *x*-ray work, one must consider (1) the static machine; (2) the induction coil; (3) batteries, primary and secondary; (4) the use of electric lighting mains (continuous and alternating current) for charging accumulators, and for direct application in *x*-ray work.

I. THE STATIC MACHINE

The special advantages of the static machine are that it is independent of dynamo or battery, and is always ready for use on merely setting it in motion, while it produces a steady discharge of electricity at an electro-motive force capable of exciting tubes of high resistance; for screen work the lighting is constant, and the apparatus is far simpler in maintenance than an induction coil outfit.

With all these advantages there are certain drawbacks. A machine suitable for work of high class is difficult of transportation owing to its bulk and weight; for the plates alone of a large machine may weigh two hundredweight. Again, the management of the conductors from the machine to the tube is difficult in the case of the static machine because the necessity for reducing all losses from leakage of current is of great importance, and the heavily-insulated conductors with knobbed ends, that must be used instead of simple spirals, do not so easily lend themselves to the innumerable shiftings of position which the adjustment of the tube to the patient may require. Lastly, the time of exposure for photography is decidedly longer with the static machine than with a 12-inch coil, although for screen work the static machine gives admirable results.

It is probable that there is room for improvement in the details of x-ray work with static machines. Hitherto they have received far less attention than has been given to the induction coil, so that, while the latter has been advanced considerably in efficiency by means of improved interrupting devices and so on, the static machine of to-day has nothing more to show than it had when applied to x-ray work three or four years ago. Much energy has been wasted, too, in trying to make the static machine portable, with the result of cramping its dimensions and spoiling it. The static machine for first-class work must be so large, and consequently cumbrous, that it can hardly be used except as a stationary apparatus attached to the consulting-room for screen examinations in general medical and surgical practice.

In the x-ray departments of well-equipped hospitals, where provision is made for carrying out regular daily work on an extensive scale, or in places where electric light is supplied by continuous current, the induction coil, driven from the mains through one of the modern forms of rapid interruptor, will meet all requirements. It is not in such places that the static machine finds its most useful field, but rather where x-rays are required occasionally, and where the maintenance of accumulators is a matter of expense or difficulty.

There are two types of statical machine used for x-ray work, namely, the Wimshurst and the Holtz. The latter is the favourite in America, but it is rarely seen in this country. It is a more delicate apparatus and more sensitive to unfavourable atmospheric conditions than the Wimshurst, but when working well furnishes a greater output of electricity.

The Wimshurst machine consists of a pair, or a number of pairs, of glass discs mounted upon a horizontal spindle in such a way that they can be made to rotate in opposite directions. The discs are fitted with pulleys, and are driven from larger pulleys attached to a counter-shaft which in turn is driven by a winch-handle or a motor, while the opposite direction of the rotating discs is obtained by crossing their appropriate belts. The discs are well varnished with shellac, and carry radial sector-shaped plates of tinfoil or thin brass upon their outer surfaces at equal angular distances. These sectors are not essential to the action of the machine, but they make it more easily self-exciting. With large machines and carefully-adjusted neutralizing brushes the presence of sectors is of less advantage, for large machines excite more readily than small.

Twice in each revolution the two sectors, situated at the opposite ends on the same diameter of each disc, are momentarily placed in metallic connection with one another by a pair of fixed wire brushes, called the 'neutralizing brushes.' The sectors just graze the tips of the brushes as they pass by.

The position of the neutralizing brushes with respect to the fixed collecting combs and to one another is variable through a certain angle; but there is a position of maximum efficiency. This position in the machine appears to be when the brushes touch the discs on diameters situated about 75° from the collecting combs, and 30° from one another.

The electricity generated by the rotation of the plates is collected by two fixed conductors furnished with collecting combs, the usual position of the conductors, which are supported on glass or ebonite pillars, being along the horizontal diameter of the disc. To these fixed conductors are attached the terminal electrodes, or dischargers, whose distance apart can be varied.

The machine is self-exciting, provided there are sufficient sectors, and generally requires neither friction nor any outside electrification to start it. In case of difficulty the neutralizing brushes must be seen to. If these be rightly placed, and make proper contacts, the machine cannot fail to excite.

In place of glass the machine can be made with ebonite plates, which are said to have certain advantages. They are not so liable to breakage during transit or in use, and they can be safely driven at a high speed. There is, however, an objection to the use of ebonite, for it gradually deteriorates on the surface, and loses its insulating properties. Moreover, plates of ebonite cannot be kept true, and give much trouble through warping; glass is therefore the best.

Mr. Pidgeon has introduced modifications into the Wimshurst influence machine by adding fixed inductors to reinforce the action between the plates, by increasing the size of the tinfoil sectors, and by carefully insulating the sectors from leakage to each other, and in this way he has succeeded in increasing, very notably, the output of a machine of a given size as compared with the output of an unmodified machine having plates of the same dimensions.

It is advised that a Wimshurst machine for *x*-ray work should have four or more plates of 36 inches diameter. Smaller machines can be used, and fair work may be done with them; but for best work at least four plates of 36 inches are recommended. The figure shows one constructed for my own use by my friend, Mr. C. L. Schwind (Fig. 2).

This machine gives streams of sparks from 10 to 12 inches long, without Leyden jars, and when running at the slow speed of 100 revolutions a minute it serves admirably for screen work, and has given fine pictures of the trunk. The plates have thirty sectors each. The stand is made of steel tubing; the hubs of the discs of gun-metal. The machine is enclosed in a glass case, to protect it from damp and from dust. It runs silently and smoothly, and has not failed to excite on any occasion during two years and more of constant use. The glass case is an essential part of any machine likely to be wanted at short notice.

In the Holtz machine all the moving plates rotate in one direction, and between them there are fixed inductor plates of glass. The excitation of the machine must be derived from an outside source in the first place, but, once excited, the apparatus will continue to produce an abundant supply of electricity so long as the rotation of the plates is continued. Usually a small accessory exciting machine is fitted in a corner of the case. The essential difference between the Holtz and the Wimshurst machines is that the former works best when discharging freely, and the latter when not discharging freely. The Holtz, therefore, is less unfavourably affected by the small leakages and brush discharges from the conductors which cannot be avoided in x-ray work; but, on the other hand, it is more likely to fail altogether in hot, damp weather. The modern Holtz machine as elaborated

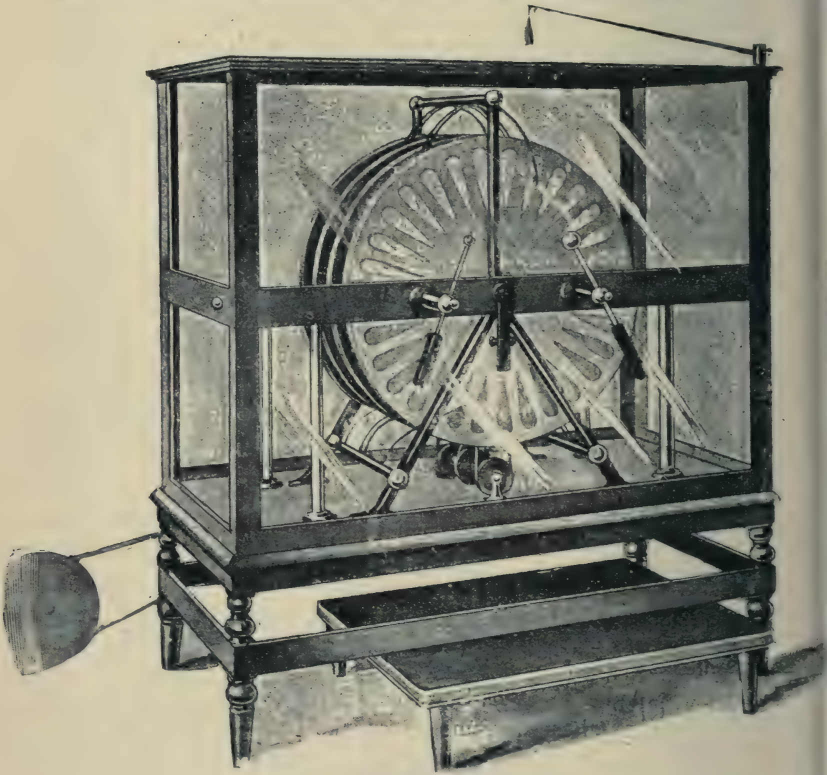

FIG. 2.—WIMSHURST MACHINE.

in the United States is considerably modified from the original types devised by Holtz himself, and is a more trustworthy instrument; for it has no tendency to lose its excitation when running, nor to reverse its polarity.

II. THE INDUCTION COIL

The Rhumkorff coil is an instrument for producing electrical discharges at a high potential when fed with current from a low-pressure source.

Energy is not in any way created in an induction coil, and owing to various losses the output of the apparatus is less than the energy which is supplied to it; therefore the great increase in the electro-motive force of the discharges of a coil is accompanied by a correspondingly great decrease in the magnitude and duration of the current as compared with the current supplied to the apparatus.

An induction coil consists of an iron core on which are wound two independent circuits of wire. These are called the primary and secondary coils. The former conveys a battery current to magnetize the core, and to set up a strong magnetic field through and around the secondary coil. The current in the primary coil is caused to vary rapidly by means of a mechanical device, or interruptor, and the rapid changes in the intensity of the magnetic field which are thus produced react upon the windings of the secondary coil and induce an electro-motive force in each turn of the wire. The sum of the electro-motive forces in all the individual windings is the electro-motive force of the whole coil.

The setting up of the magnetic field when the current is 'turned on' in the primary is a slower process than the disappearance of the magnetic field when the current is broken, and the rate of change of the magnetic field being a factor of prime importance, the electro-motive force induced in the secondary coil at the 'break' is by far the greater.

In working with *x*-ray tubes the current induced at 'make' may be disregarded, as its electro-motive force is considerably below that at 'break,' and is not sufficient to excite the tubes. This is fortunate, because the 'make' current would be in the wrong direction when the current at 'break' is right for the excitation of the tube.

The primary winding of a large coil is of thick copper wire, for it has to carry currents of considerable magnitude without becoming heated. The core is made of a bundle of fine iron wires carefully annealed to facilitate the magnetic changes which are to take place in them. The secondary coil is of fine wire carefully covered with silk insulation, and ten miles or more may be required.

To secure a good and lasting insulation of the secondary coil is essential. The core is wrapped in varnished tape, and, after being wound with the primary wire, is usually enclosed in a thick vulcanite tube. On the latter the secondary wire is wound in layers, separated from each other by paraffin-paper, or by shellac varnish in certain cases, particularly for use in hot climates. When finished, the whole is carefully soaked in melted paraffin. For small coils the secondary is wound in single layers along the length of the bobbin, like cotton on a reel; but in large coils it is best wound in two or in many sections, an arrangement which may be compared to a row of reels arranged side by side on a spindle, with the ends of cotton carried from one reel to the next.

A 12-inch coil may have seventy or eighty of these sections arranged side by side and separated from one another by thin discs of ebonite.

The appearance of the completed coil is well known (Fig. 3), and the diagram of its construction may be seen in Fig. 4.

In a box below the board on which the coil is mounted, and forming part of the base of the instrument, is placed the condenser. This consists of a number of sheets of tinfoil insulated from each other by sheets of paraffin-paper. The metallic sheets are connected in two sets, the even numbers on one side being connected to one of the two supports of the contact-breaker, and the odd numbers on the other side to the second support. The object of the condenser is to demagnetize as quickly as possible the soft iron core, as the length of the spark depends upon the suddenness with which this is accomplished. When the current from the battery is broken, an electro-motive force is induced in the primary wire in the same direction as that of the primary current, and this discharges into the condenser first, and from the condenser it traverses the primary windings, producing a momentary reverse current in the primary wire, and thereby favours the instant demagnetization of the core.

At the side of the contact-breaker is usually found a com-

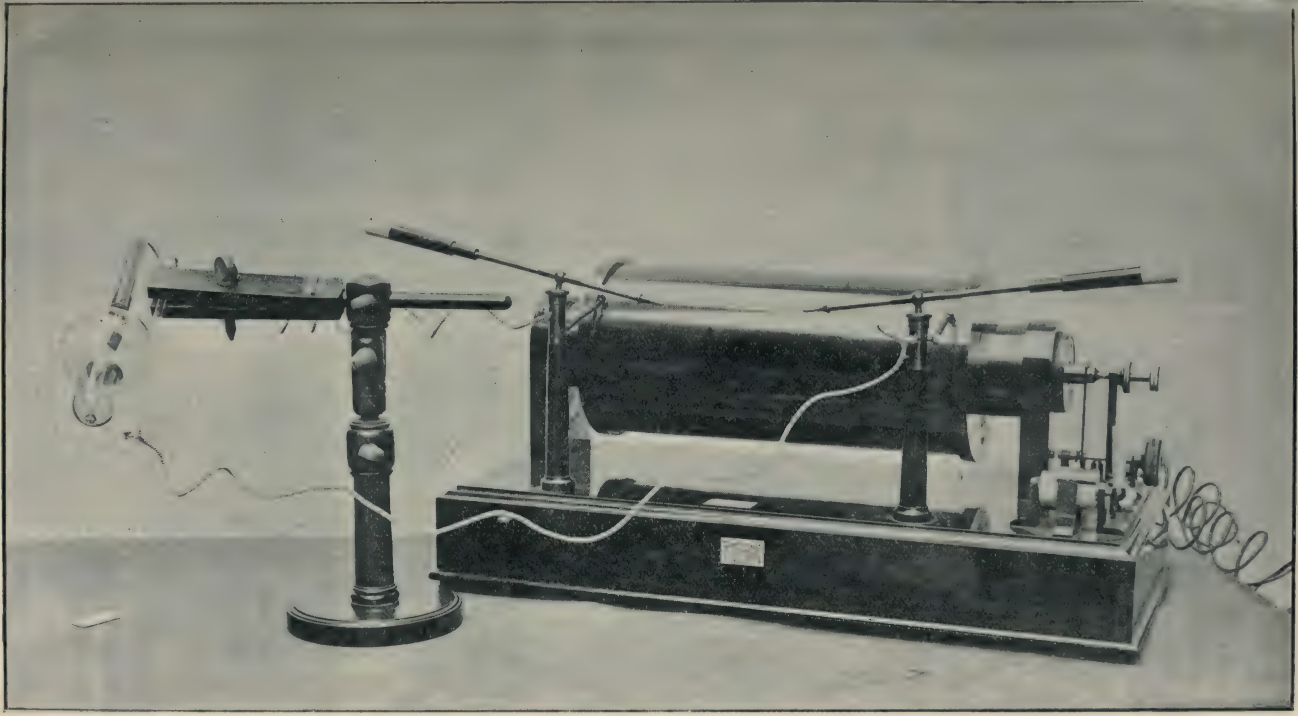

FIG. 3.—APPS-NEWTON 10-INCH SPARK COIL, CONTACT BREAK, AND TUBE WITH SPECIAL INDIARUBBER PROTECTOR (WEBSTER'S).

mutator switch for connecting the coil to the battery or for changing the direction of the current in the primary circuit.

The break or interruptor is an essential in the working of the induction coil. Various interrupting devices are used, the simplest of them being the so-called vibrating hammer. An upright spring, armed at one end with a heavy piece of iron, is fixed on the base-board, so that the head of the hammer is exactly opposite the centre of one end of the core of the coil, at a distance of about $\frac{1}{3}$ inch. Fixed to the hammer, on the face away from the core, is a piece of thick platinum, and opposite this, on a brass pillar fastened to the base, is a screw carrying at its point another piece of platinum. Connections are made underneath the base-board, so that the current to the primary coil must pass through the junction of these two pieces of platinum and their supports. The current magnetizes the soft iron core, which then attracts the iron hammer, and so draws apart the two platinum points; when these are separated the circuit is broken. The current ceasing to flow, the core is demagnetized, and no longer attracts the hammer, which falls back to its original position, when the current flows again into the primary and the process is repeated. The screw C B (Fig. 4)

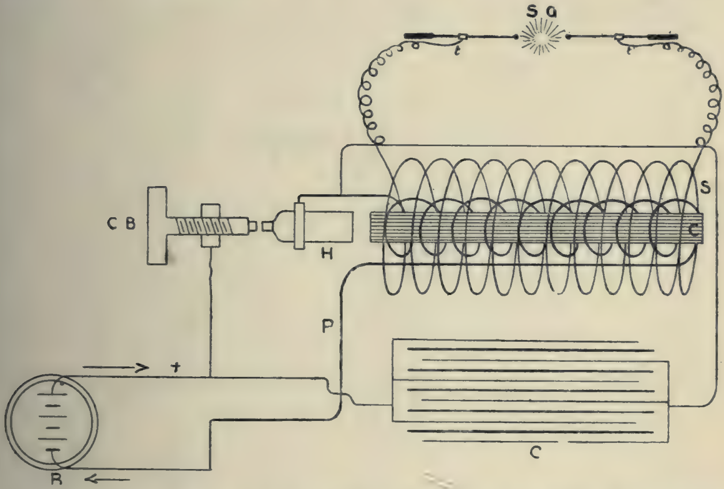

Fig. 4.—Plan of Coil: C B Contact Break. R Battery. P Primary. S Secondary. C Soft Iron Core (inside primary). H Hammer. C Condenser (lower part of figure). S G Spark Gap.

serves as an arrangement for adjusting the distance of the hammer from the iron core, while the tension of the spring is regulated by a screw that can be made to stiffen the hammer-spring, and thereby to hold the platinum points together against the attraction of the core, and thus to prevent any break of circuit occurring before the magnetism of the iron core has reached a proper degree of saturation. The greater the tension of the upper screw (provided it be not made so tight as to stop the vibrations), the longer will be the sparks given out by the coil, and it is by careful regulation of the tension screw that the working of the coil is adjusted to suit the various tubes employed in x-ray work. It is as well to note that the contact-breaker works best when the face of the iron hammer is kept close to the end of the core.

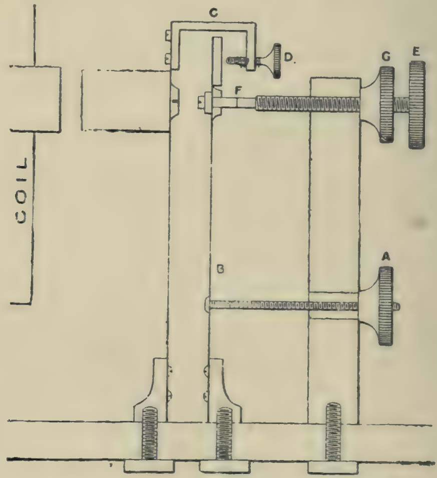

Fig. 5.—Vril Contact-breaker.

The Vril contact-breaker is a modification of the foregoing. It was devised by Mr. J. King, A.M.I.C.E., and is made by W. Watson and Sons. It will be seen from Fig. 5 that the iron hammer is mounted as usual, but the platinum contact is carried by an intermediate spring, B.

When in action, the attraction of the hammer by the core causes the point of screw D to impinge on the top of spring B, so causing a separation of the platinum points, F. The advantages claimed for this break are that a more prolonged contact is afforded, giving time for the thorough magnetic saturation of the core; that in consequence there is an economy in the expenditure of battery power as compared with ordinary patterns, and that the break is more sudden and the liability to burning of the platinum contacts is diminished, while 'sticking' is almost impossible. It is a good form of break. Similar forms of breaks are fitted to coils by other makers, and in some of these an independent electro-magnet is used to operate the movement.

Many workers with Röntgen rays still use the ordinary vibrating spring contact-breaker described above, and for photographic work this contrivance gives very good results even with coils giving sparks up to 12 inches. For screen work the flickering illumination given with this form of contact-breaker is disagreeable, and more rapid breaks are necessary to produce the effect of steady illumination of the screen. There are two kinds of rapid break: the mechanically-driven mercury break and the 'electrolytic breaks' of Wehnelt and Caldwell.

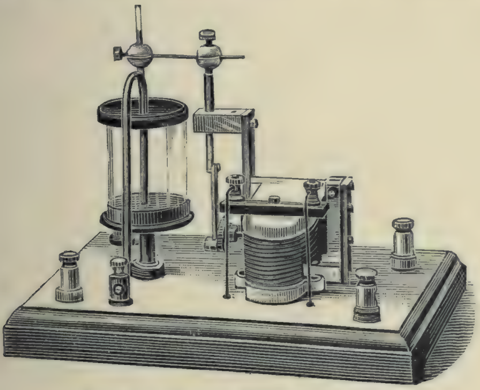

FIG. 6.—MOTOR MERCURY BREAK.

Mercury Breaks

Of the former class three types may be noticed. In one the contacts are made and broken by a rod which is made to dip into and out of mercury (see Fig. 6). The movement of the mechanism is usually effected by a small electro-motor driven by an independent battery, and the speed can be varied by the regulation of the current supplied to the motor. The range of movement of the rod which dips into the mercury can also be adjusted, and the best conditions are obtained when the rod is in contact with the mercury for the greater part of each cycle, and is out of the mercury for a relatively short period. This is necessary because the growth of current in the circuit is not instantaneous at the moment of contact, and time is needed for the magnetic saturation of the core. To diminish oxidation from sparking, the surface of the mercury is covered with petroleum or alcohol or water.

The second type of mercury break is best illustrated by Mackenzie Davidson's recent instrument (Fig. 7), in which the contacts are made by a radial arm projecting from a rotating spindle, and coming in contact with mercury as it revolves. This, too, is driven by an electro-motor, and the action of the break occurs beneath a layer of paraffin oil. When properly made the Mackenzie Davidson mercury break is at once the best and cheapest of its class.

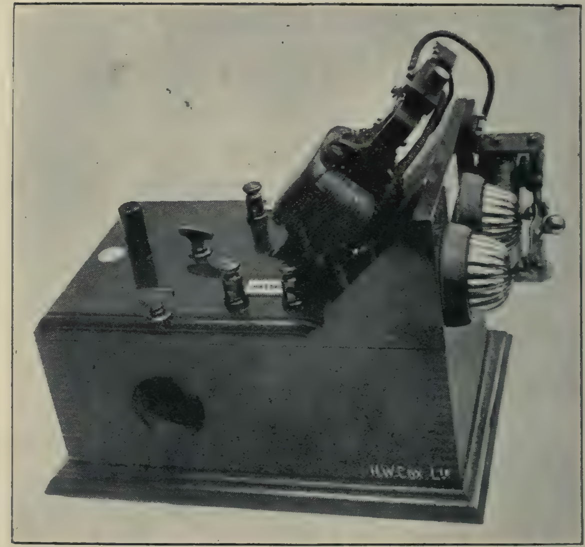

Fig. 7.—Mackenzie Davidson's Mercury Break (with latest improvements by Mr. H. W. Cox).

A third type of break has a jet of mercury which impinges upon a rotating metallic surface with apertures cut in it. The turbine break and Max Levy's break are of this kind.

All high speed breaks require high electro-motive forces to give good results. Consequently there is not much advantage in using a rapid break unless a good number of accumulator cells can be used. If an experiment be tried, it will be found that the sparks given out by a coil fed from a small number of cells will become feebler as the speed of the mechanically-driven break is increased, while if the number of accumulator cells in circuit be increased the sparks will become longer for the same speed of breaking circuit.

On the other hand, with a vibrating spring contact-breaker the electro-motive forces applied to the coil cannot safely be increased beyond a certain point, whereas with a sufficiently rapid break electro-motive forces up to 100 volts or higher may be used with advantage, provided the speed of the break be increased in due proportion, and in this way we arrive at the direct employment of the electric lighting mains (continuous) for working x-ray coils, a method which is only possible with rapid contact-breakers.

Electrolytic Breaks

The most rapid break of all is the electrolytic break of Dr. Wehnelt. This depends for its effect upon the formation of bubbles of gas at the poles of an electrolytic cell. When one pole is of small surface, the bubbles of gas formed there render the current intermittent, the interruptions following each other with extreme rapidity.

It is interesting to note that Spottiswoode employed a contrivance of this kind for use with coils, and spoke of interruptions with a frequency of 1,000 a second obtained in that way.

Wehnelt's break, as usually constructed, consists of a glass jar or vessel filled with dilute sulphuric acid; the kathode is a sheet of lead, while the anode is a platinum wire insulated except at its extremity, which is deeply submerged in the electrolyte. Means are provided for increasing or decreasing the exposed area of the platinum. When a steady electro-motive force, which must be of at least 24 volts, or higher, is applied to the apparatus, arranged in series with the primary circuit of a coil, the discharge through the circuit thus formed becomes intermittent, a peculiar shrill note is given out by the electrolytic cell, and streams of sparks are given off by the secondary coil. The contact-breaker proper of the coil must be screwed down, and this puts out of gear the condenser, but the coil works perfectly well without any condenser. It is important to see that the electrolytic break is not connected up to the wrong poles of the circuit.

In Wehnelt's apparatus the intermittent character of the discharge is due to the formation and dissipation of gas bubbles at the anode. There is a modification of the apparatus of a fundamental kind, due to Caldwell, and independently to Simon, and their apparatus is likely to supersede the original pattern.

These observers bring about the formation of bubbles of gas at a point in the cell remote from the poles, and thereby secure several advantages. The form of liquid interruptor which is now in general use in this country is known as Campbell Swinton's modified Caldwell interruptor. It is a cell containing the usual electrolyte, dilute sulphuric acid, and two plates of lead for anode and kathode. A partition of glass or porcelain separates the cell into two parts, each containing one of the metallic poles. The partition has a small hole through which the liquids in the two portions of the cell communicate. Owing to the high density of the current at this narrow opening, this portion of the circuit becomes heated, and bubbles of gas (steam) are generated there and break the circuit; the bubbles are almost instantaneously

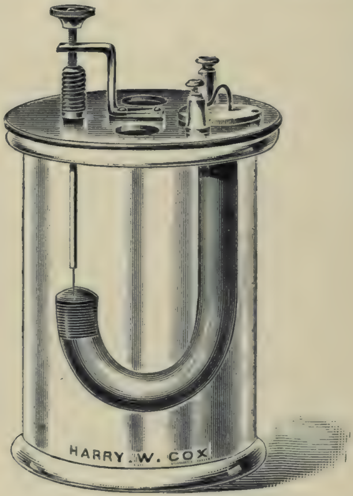

FIG. 8.—IMPROVED WEHNELT INTERRUPTOR.

dissipated and as quickly renewed, the rate being in part determined by the size of the hole.

In its usual form (Fig. 9) the apparatus consists of a wooden box containing a glass receiver with an inner cylindrical vessel of glass, suspended so that it does not rest upon the bottom. This inner cylinder has a small hole at the lower end about 3 or 4 millimetres in diameter. Into this hole projects the conical end of a glass rod fixed in a vertical position and attached to an adjustable screw so that it can be raised or lowered as required. In this way the aperture can be opened or closed wholly or in part by altering the position of the rod. The frequency of the interruptions also varies as the size of the aperture is altered.

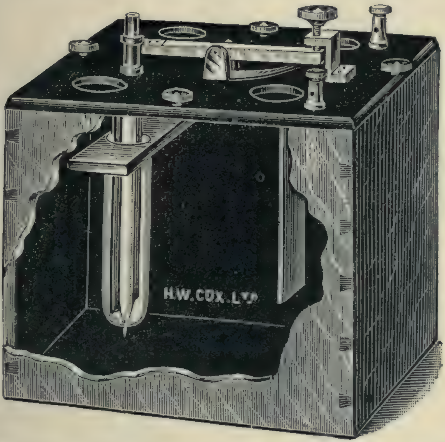

Fig. 9.—Caldwell-Swinton Liquid Interruptor.

Connections are made by means of terminals attached to two lead electrodes dipping into the inner and outer vessels respectively. When operating, the liquid is found to rise in the inner cylinder, which is accordingly provided with an overflow channel through which the liquid returns into the outer vessel. As both poles are of lead and of large area, there is no special need to make the connections in one particular way as required for Wehnelt's form.

With either of these liquid interruptors, the appearance of the discharge of a coil is considerably altered. The sparks from the secondary terminals follow one another so rapidly as to give the appearance of torrents of sparks passing simultaneously, and with pressures approaching 100 volts, and adjustment for the highest rate of interruption, the discharge has the form of an arc of pale yellowish-green flame. For use with x-ray tubes it is best not to drive the rate of interruption too high, as few tubes will stand the discharge. The higher the pressure the more rapid is the break, and the smaller the aperture (Caldwell) or the exposed platinum (Wehnelt) the more rapid are the interruptions.

Mr. Harry Cox has brought out a form of Wehnelt break which is said to work smoothly and quietly, and to be free from the tendency to 'fatigue' exhibited by the earlier forms of the apparatus. In this instrument (Fig. 8) the kathode has the form of a curved lead tube, and the anode consists of a thick copper wire which lies concentrically within it, and is tipped with a platinum wire projecting for some distance, while the copper conductor in the interior of the leaden tube is embedded in an insulating material. The discharge from anode to kathode through the electrolyte is regulated by a glass sleeve or tube which slides over the exposed platinum wire so as to leave more or less of its surface uncovered as may be desired.

III. THE ACCUMULATOR, OR STORAGE BATTERY

The typical x-ray set is usually driven by accumulators, from eight to ten cells (16 to 24 volts) being customary for a 12-inch spark coil. Where outside recharging is easy to obtain, the employment of accumulators gives no trouble; but under certain circumstances the cells may have to be charged at home, and the question of means must be considered. The possibilities in this case are as follows:

1. The use of primary batteries.
2. The use of a dynamo driven by power.
3. The use of the electric light mains.

And under these headings may be found a large number of problems and combinations.

First as to primary batteries. Accumulators may be charged in this way without any difficulties except those which attend the handling and management of primary batteries. Such drawbacks, however, are by no means light, as the preparation of batteries is a tedious and disagreeable task. Several types of primary cell have been recommended; the Daniell, the bichromate, the Bunsen, and the copper oxide (Lalande and Chaperon and 'Cupron'* element) all can be used. The Daniell cell can be trusted to give a steady current for a twenty-four-hours run when properly set up, and in that time should be able to give a charge of, say, twenty-four ampère-hours to the accumulator. The electro-motive force of the Daniell cell may be taken as 1 volt, while that of an accumulator cell is 2 volts. Two Daniell cells are required, therefore, to balance the back electro-motive force of each cell of the accumulator to be charged, and consequently, for charging purposes, the battery of Daniell cells must consist of more than this number for each accumulator cell. To charge at a reasonable rate three cells must be used for each accumulator cell, and this in the case of an eight-cell accumulator means twenty-four cells, demanding a considerable first cost, and a great amount of labour in preparing the cells and in cleaning after use. The Daniell cell must be used as soon as it is set up, for it will not remain long in good condition on open circuit. Accumulator cells cannot be kept in proper order unless they are recharged

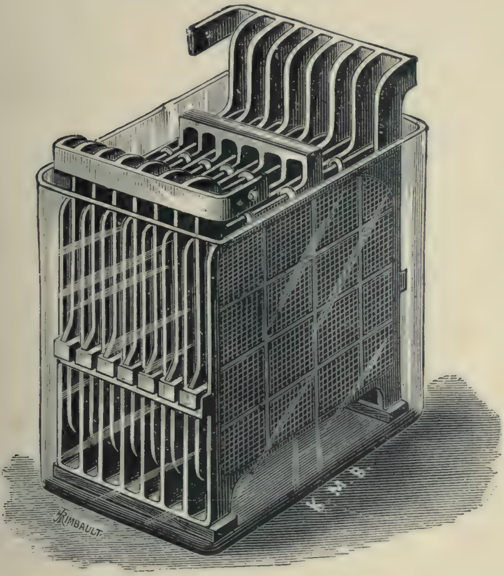

Fig. 10.—Accumulator Cell.

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* The Accumulator Industries, Ltd., 14, Silver Street, Bloomsbury, W.C.

frequently; indeed, the recharging ought to be done every week, or every fortnight at the outside, and it is probable that very few of those who use x-rays would be found willing to face the work of keeping them properly charged from primary cells. The Bunsen and the bichromate cells have an electro-motive force which is nearly twice that of the Daniell cell, and a fewer number of cells would be required, but they have defects of their own. The former can only be used in an outhouse or a fume-chamber, because of the poisonous gases which they emit, and the latter are inconstant, and cannot be counted on for a run of more than an hour or two at a time. There is a modification of the Bunsen cell in which the nitric acid is replaced by a mixture of dilute sulphuric acid and chlorate of potash, which has certain advantages and might be tried.

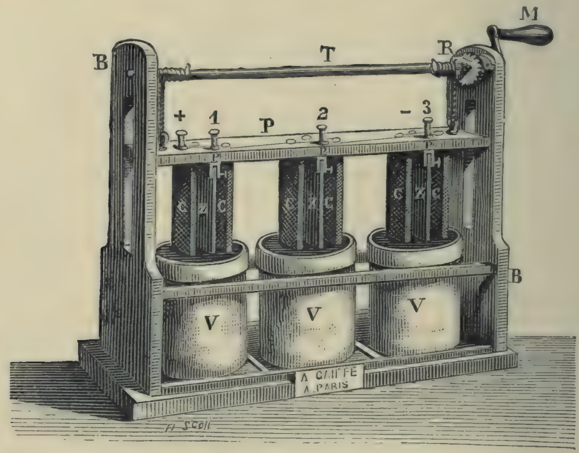

Fig. 11.—Bichromate Battery.

The copper oxide cell of Lalande and Chaperon, with its modification by Edison and its more recent form, the 'cupron' element, have a lower E.M.F. (·8 volt) than the Daniell, and therefore an even larger outlay in primary cells is necessary in their case. Practically the recharging of accumulators by primary cells is out of the question for serious x-ray work, and it is doubtful whether there is anyone who makes use of the method. For a small coil requiring less power to drive it, and for amateur work the recharging from primary batteries might be attempted, but for such light work primary batteries might be connected directly to the coil. The direct use of primary cells for driving large coils is not impossible, although it is rarely practised. Most primary cells are unsuitable because they have too high an internal resistance, and therefore cannot furnish currents of sufficient magnitude. The only practical cells which are made in sufficiently large size for the purpose are the Edison-Lalande, the 'cupron' element, and the bichromate, with some contrivance in this last case for lifting the plates out of the liquid during the periods of rest. The copper oxide cells in their largest forms would probably work *x*-ray coils quite well, and when once set up would keep in good order for many months before needing any renewal of parts or of exciting liquid. They consist of zinc and copper oxide plates in strong caustic soda solution. The internal resistance is very low, and the cells will give a discharge of 5 or 6 ampères ; with twenty cells a large coil should work fairly well, but the first cost of the battery would be nearly £20. When once set up, these cells give 500 ampère-hours before needing to be renewed. They do not deteriorate when left to themselves on open circuit, and the renewal of parts is not a serious expense.

Recharging from a dynamo machine driven by power is a more practical way of working. Here the chief difficulty is that connected with the source of the power. Opportunities for using a water-motor, a windmill, or horse or man power for accumulator charging are exceptional, and need only be mentioned here. The use of a tandem bicycle, with the hind-wheel raised off the ground and belted to a dynamo, will be remembered in connection with Major Battersby's admirable work in the Soudan campaign, and the same means of charging cells has been used more recently in South Africa. Direct driving of the coil from a dynamo worked in this way is quite practicable. A one-quarter-horse-power dynamo has a calculated output of nearly 200 watts, equivalent to 4 ampères at 50 volts, or 8 ampères at 25 volts. For field-work in time of war, perhaps the simplest device of all would be a motor tricycle fitted up to carry the coil, etc., when on the march, and to drive a dynamo by means of its engine when wanted for *x*-ray work.

Where power can be obtained the process of charging presents few difficulties. The dynamo must be shunt-wound, and, unless specially designed to suit the battery it is to charge, there must be some form of regulating resistance to protect the cells or the dynamo itself from damage by excess of current. The simplest outfit is a small gas-engine and dynamo, and if there is a considerable amount of work to be done—as, for example, in hospital work—the cost of a half-horse-power engine and dynamo is not prohibitive. For gas the cost is about £25, and the same outfit for use with oil instead of gas comes to £35. In this connection it is important to note that miniature gas-engines are now receiving attention from the makers, and a machine of one-eighth of a horse power, and capable of steady running, is now to be bought, which should be the very thing for charging accumulators for *x*-ray sets. Gas-engines by inferior makers must be avoided, as they are apt to be troublesome.

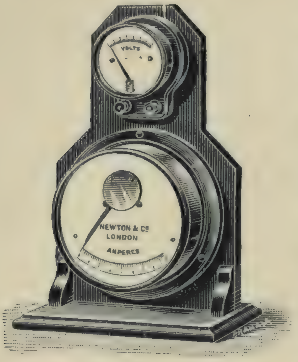

FIG. 12.—VOLTMETER AND AMMETER.

IV. THE USE OF ELECTRIC LIGHT MAINS FOR BATTERIES AND COILS

In places supplied with constant current for electric lighting the accumulators can easily be kept in good order and fully charged by connecting them to the mains through a lamp or other resistance, and leaving them there as long as may be necessary. The more often they are charged the better it will be for the cells. Thus, if the accumulators have a capacity of 20 ampère-hours, and current is taken from them to the extent of 2 ampère-hours daily, it would be better to recharge to that extent daily, and not to wait until the cells were completely run out before starting to recharge them. No harm can be done to the cells through charging them too long or too often.

The rate of discharge of the cells when working the coil can be measured with sufficient accuracy by an ammeter, and this figure (ampères) multiplied by the time of working (expressed in hours or minutes) gives the ampère-hours or ampère-minutes of the discharge from each cell; and, similarly, the rate of charge from the mains, in ampères or fractions of an ampère, multiplied by the time in hours, gives the ampère-hours of the charge. It is useful to know that on a 100-volt circuit a battery of eight or ten accumulators would be charged at the rate of about half an ampère through a sixteen-candle-power lamp, and at twice that rate through a thirty-two-candle-power lamp.

To charge from the mains with a lamp in series, the battery must be connected so that the current which goes through it must also go through the lamp. In the case of a lamp suspended by a flexible wire the conditions would be met by cutting one of the two strands of the double wire, and untwisting the cut ends for a few inches so as to give sufficient length for connection to the two ends of the battery. As one of the severed ends is positive and the other is negative, there will be a right and a wrong way of connecting up. In the former the direction of the current from the main will be opposed to that of the battery, the lamp will burn more dimly, and the battery will receive a charge. In the latter it will not receive a charge, but, on the contrary, it will discharge, reinforcing the current of the main, and the lamp in the circuit will burn too brightly. The effect on the lamp is the simplest guide to the right way of connecting in the battery, and when once determined the ends may be marked in some way for future guidance. Another way of testing the polarity of the ends of wire is to lay them on a piece of wet litmus-paper; the paper will be reddened where it touches the positive pole, and turn blue where it touches the negative.

If, instead of considering a flexible wire divided as just described, we consider a piece of electric light wiring enclosed in the ordinary wood casing, it will be seen that the same results can be obtained by removing a few inches of the casing cover; one of the two wires can then be cut and the ends bent up a few inches apart and brought through holes in the cover, where they may be attached to binding screws for the sake of neatness. The battery can then be attached to these binding screws by means of wires when it is wished to charge, and when charging is not in progress the battery can be detached and removed, and the binding screws directly connected to each other by a neat connection of wire. The lamp will then be ready to give light if required for that purpose.

Ready-made appliances for charging through a lamp can be bought from the instrument-makers. Usually they consist of a board carrying one or more lamps in sockets with a pair of charging terminals, and a flexible wire with plug for attachment to wall-socket or lamp-socket, as may be desired. It is as well to bear in mind that with the ordinary lamp-socket with bayonet-catch there are two possible positions of insertion of the lamp or plug, and therefore the binding screw which is positive for one way will be negative for the other. With *concentric* wall-plugs the polarity is always the same.

For much useful information and tables of rate of charging of batteries from the mains, etc., see 'Portative Electricity,' by J. T. Niblett (Biggs and Co., Salisbury Court, E.C.).

The existence of continuous current mains, while simplifying the process of charging accumulators, at the same time does away with the need for accumulators to a great extent. The direct driving of x-ray coils from 100-volt mains with the aid of modern rapid interruptors will be preferred in most cases for work in the place where the mains are to be found, though there will still be some small need for accumulators in such a case when the coil and x-ray outfit has to be transported to the bed-side of a patient.

The last case to be considered is the charging of accumulators in a place supplied by alternating current only. Alternating current cannot be used directly for charging accumulators, but much ingenuity has been devoted to the solution of the problem of making indirect use of it for the purpose. So far there is no very convenient and cheap method. The aluminium cell is a device which depends upon a peculiar property of that metal, in that when it is made the anode of an electrolytic cell it offers a very considerable resistance to the passage of current, although when it is the kathode this is not the case. Consequently, when supplied by alternating current, a cell with one carbon pole and one aluminium pole immersed in alum solution will stop one set of alternations and allow the others to pass, making out of the alternating current a current which is unidirectional and pulsating. This 'valvular' effect fails with pressures over 20 volts, and when the electro-motive force of the charging current is higher than this an appropriate number of aluminium cells, arranged in series with each other, becomes necessary. By this means it is possible to charge secondary cells from the alternating mains; but after a few hours' use the aluminium plates corrode, and their renewal becomes troublesome. The method has therefore not been widely adopted.

Another method of utilizing the alternating current is to use it to drive an alternating motor, and to cause this motor to drive a direct current dynamo from which the current is drawn for the charging of the cells. This method presents no difficulties except that of first cost, and has been in use in the electrical department at St. Bartholomew's Hospital for some time.

The next step is to combine motor and dynamo into one instrument, and this is now being undertaken by Mr. Marshall, of 2, Gray's Inn Road, who has kindly sent the following account of his machine.

Alternating Current Rectifier

This machine will change alternating current into a unidirectional current suitable for charging accumulators and so on. It consists of a synchronous alternating current motor, with a double winding on the armature. One winding is connected with a pair of insulated metal rings which receive the alternating current through copper brushes; the other winding is connected with a commutator from which continuous current is collected by a pair of copper brushes, the voltage being in constant and definite ratio to the supply voltage. This ratio can be arranged to suit the number of cells which it is required to charge—*e.g.*, 18 volts and 3 ampères to suit a six-cell accumulator. The method of using the machine is as follows: The accumulator is first connected through an adjustable resistance to the terminals on the commutator side of the machine, which then starts as an ordinary direct current motor driven by the accumulator current; as soon as the armature rotates with a speed such that it is in step with the frequency of the supply circuit, the alternating current is switched on to drive the machine, which then runs in step as a synchronous alternating motor giving out direct current into the cells. The machine is self-exciting, and can also be made to serve as a motor to drive a lathe or any small machine requiring one-quarter horse-power or less. The speed will vary according to the frequency of supply: with a frequency of 100 periods per second the speed will be 1,500 revolutions per minute; a lower frequency will give a proportionately lower speed. If the machine is to be used for working a Wehnelt interruptor, a second commutator is added, and the current used for the interruptor is not drawn from the coils of the machine, but is simply rectified in the second commutator, the machine being started up to synchronous speed by means of the cells as before, and the cells being switched off as soon as this speed has been attained, and the alternating current switched on in its place.

The instrument is supplied either with single commutator, suitable for charging an accumulator such as is generally used for working an *x*-ray spark coil, or with a second commutator and choking coil for use with liquid interruptor.

Dr. Morton of Taunton has recently described and exhibited a rectifier which works admirably in his hands, both for charging accumulators and for working *x*-ray coils direct. The principle of his machine is a commutator driven at a uniform speed by the alternating current itself. The commutator is mounted on the axle of a small motor which runs in true synchronism with the pulsations of the alternating current; the commutator segments therefore change in sign in step with the change of sign of the alternations of the current, and they pass under the collecting brushes at such an interval of time that the segment under one brush is always positive, and that under the other is always negative. The current led off from these brushes is therefore unidirectional and pulsating, and will charge an accumulator.

Yet another apparatus, shown in 1901 before the Röntgen Society by Dr. Hadden, has a magnetic tongue or spring vibrating between the poles of an electro-magnet fed with the alternating current; the polarity of the electro-magnet changes at each alternation of the current, and the moving spring is accordingly attracted to the one side or the other in turn, and in its movement between two contact-points it is made to 'commutate' the alternating current and rectify the impulses so that they succeed each other in one direction. This ingenious contrivance deserves further attention on account of its simplicity. It is perhaps best suited for charging accumulators at a slow rate, though it was shown by the inventor in actual work upon the more difficult duty of driving a coil direct with a Caldwell interruptor in circuit.

The direct application of the alternate current mains to the excitation of induction coils has been tried, but only with limited success. When a coil of ordinary construction with vibrating interruptor is fed by an alternating current it works very much as when supplied with a battery current, but the appearances in the x-ray tube show that the discharges of the secondary coil are not all in one direction, and the phosphorescence of the tube is therefore irregular. This would be obviated if the contact-breaker could vibrate in step with the periodicity of the current. The introduction of the electrolytic interruptors has attracted fresh attention to the problem, because it has been noticed that there is a certain natural tendency on the part of electrolytic breaks to 'rectify' the alternating current by transmitting the pulsations in one direction more readily than in the other, and it has been claimed that this or that make of liquid interruptor can be used with the current of the alternating mains. A recent article by Dr. Dujon* describes his experiences and method. He states that he obtains first-rate results, and that the discharge of his 14-inch spark coil was absolutely unidirectional, so that reversing the commutator of the coil had exactly the same effect as if he had been using a battery current. His voltage of supply was 110, and the periodicity was 53 per second. Apparently the full pressure of the mains was best, with the ammeter in the primary circuit reading between 4 and 10 ampères; but a certain amount of graduation was possible by adjusting the amount of exposed platinum in the Wehnelt to suit the alteration in the voltage. A minor difficulty was the overheating of his tubes, and this, too, suggests that regulation was somewhat difficult.

A point of importance, probably, in his success was the low periodicity of the current employed. In London the usual periodicities of alternating supply currents are much higher, 80 to 100 being usual, and the self-induction of large coils, as usually wound, is so great that at these high periodicities very little current will go through the primary from a source at 100 volts, even when there is no interruptor in the circuit at all.

High Potential Transformers.—Several important papers have appeared in the *Archives d'Électricité Médicale* for 1900 and 1901 on the use of transformers wound to give an electro-motive force sufficient to work x-ray tubes directly. The transformers are worked from the alternating mains, and take the place of the coil. The current they give out is, of course, an alternating one; but M. Villard, the writer of the papers referred to, has invented an extremely ingenious device for correcting this. He uses a vacuum tube one of whose poles is a straight fine wire in a narrowly-constricted part of the tube, whereas the other pole is a long helix suspended freely in a wide, globular portion of the tube. A tube of this kind will transmit current freely when the helix is negative; but when the wire in the narrow portion is negative it transmits little or none. M. Villard arranges one of these valve tubes in series with the x-ray tube, and obtains very good results. His transformer is oil-immersed, wound in two separate portions, and raises the electro-motive force to 50,000 volts. By inserting two valve tubes, or throttle-tubes (*soupape*), he is able to use both alternations of the current, and direct them both in the right direction through his x-ray tube, or—and this is still more important—he can illuminate two separate tubes alternately, thus securing the best possible effect for stereoscopic radioscopy. His papers are fully illustrated, and form a most important contribution to x-ray literature.

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* *Archives d'Électricité Médicale*, April, 1901.

V. THE VACUUM TUBE

Soon after the invention of the induction coil, it was found that a spark which passed with difficulty in air did so much more readily in a partial vacuum. A glass tube having a piece of platinum wire sealed into it at each end, and the air inside it exhausted to one-hundredth, becomes filled with a luminous glow on passing the discharge of a coil through it, and if it be examined with a spectroscope it will show the characteristic lines of the residual gases, namely, nitrogen and oxygen in the case of air, or of any other gases which may be introduced into it before the exhaustion. This apparatus was named the Geissler tube, and has been made in infinite variety of form on account of the beauty of the luminous effects produced. The gas at low pressure in these tubes conducts better than air at the ordinary atmospheric pressure, and a tube 6 or 8 inches long can be well lighted up throughout by a coil whose sparking distance in air is less than 1 inch. The various appearances in these tubes, and their changes as the exhaustion of the air was increased, were carefully investigated by De la Rue and Spottiswoode. Beyond a certain degree of exhaustion the resistance of the tube increases again, and the luminous appearance inside the tube becomes fainter, until at last it disappears, and in its place one sees a brilliant phosphorescence of the glass wall of the tube, which otherwise appears dark and empty. The phenomena at these high exhaustions were studied by Crookes, and illustrated and explained by him in a brilliant research. It is necessary to carry the exhaustion to about one-millionth of an atmosphere to produce his results, which he proved to be caused by the action of the negative pole (kathode) in causing a stream of gaseous molecules to be propelled from the surface of the kathode. These molecules were free to move, owing to the tenuity of the atmosphere inside the tube, and travelled at a high velocity until they struck some solid object, usually the wall of the tube itself, where their energy was expended in producing phosphorescence of the glass and heating it. The study of the kathode rays was pursued still further by Lenard, who showed that effects of radiation could be detected in the space outside the walls of the tube by the production of phosphorescence, and by an action upon photographic plates. It was while investigating this part of the subject that Röntgen made the discovery of the rays to which he gave the name of x-rays. The x-rays are produced when the kathode rays strike a solid object, and the surface which they strike is their source of origin. They have the special property of penetrating substances opaque to ordinary light, and of doing this proportionately to the density of the substances. On this fact depends their interest and great utility. The x-rays, or, as they are now often named, the Röntgen

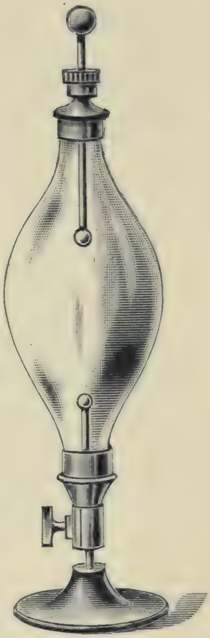

FIG. 13. — ELECTRIC EGG,* BY WHICH EARLY VACUUM EXPERIMENTS WERE CONDUCTED.

Air is withdrawn by attachment to an air-pump.

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* From Addyman's 'Practical X-Ray Work.'

rays, like the actinic rays, produce fluorescence and photographic action.

The next step in the application of this discovery was to find a suitable form of vacuum tube for practical use, and with this object numerous tubes have been made in a great variety of shape. In the earlier tubes the kathodic bombardment was projected on the surface of the glass tube opposite the kathode, but the form now adopted in all tubes is that introduced by Mr. Herbert Jackson, who devised a tube with a metallic target, so placed inside it as to be near the focus or point of convergence of the bombardment from a concave kathode. By this device the definition of x-ray photographs is greatly improved, the x-rays arising from a small area of the platinum target, and not, as in the other tubes, from a large area of the glass wall of the tube. The kathodes in all forms of vacuum tube must be made of aluminium, because this metal does not become disintegrated under the action of the discharges. Most metals are thrown off in minute particles, and are deposited as a film upon the adjoining parts of the wall of the tube. For the anti-kathode a dense and infusible metal is required. Platinum is generally used; osmium and osm-iridium alloys are even better, but the expense attending their use is an obstacle. The platinum target or anti-kathode is fixed at an angle with the axis of the tube in order that the main part of the Röntgen rays may be directed to one side of the tube, and hence may be readily thrown upon the object to be investigated, and on the fluorescent screen or the photographic plate. The original form of Jackson's 'focus' tube is

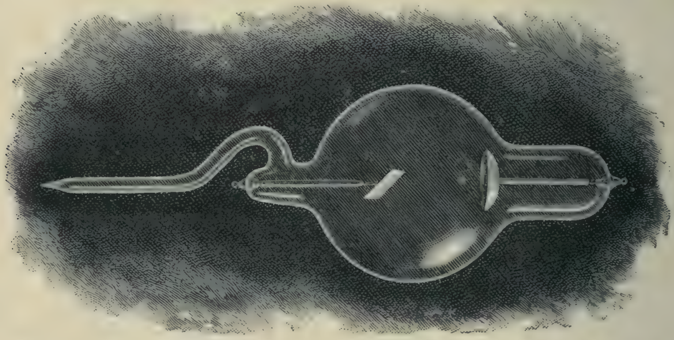
FIG. 14.—FOCUS TUBE (FROM LEWIS WRIGHT'S 'INDUCTION COIL').

shown in Fig. 14. The cup-shaped kathode is of aluminium, the target or anti-kathode of a sheet of platinum obliquely inclined, both being in communication with the exterior of the tube by platinum wires sealed through the glass. The anti-kathode acts also as the anode of the system. The wire stems of both electrodes are provided with sleeves or sheaths of fine glass tube which tends to concentrate the discharges at their terminal surfaces.

Among the modifications of form which the focus tube has since undergone, the chief has been the introduction of a third electrode. This has come into very general use, and it is believed to act as a steadier of the tube. After long use the resistance of an x-ray tube increases, until in time it may become too high for the coil for which it was originally fitted, and it is then useless unless a more powerful coil can be obtained. Tubes with a third electrode vary less in their resistance than do the older tubes without a third electrode. The resistance of a tube increases with the exhaustion, and the one chosen for use should be proportioned to the size of the coil with which it is intended to be used. When from long use its resistance has become too high, it can be reduced for a time by heating the tube with a spirit-lamp. It is said that a tube can be brought back permanently to its original resistance by prolonged baking in an oven.

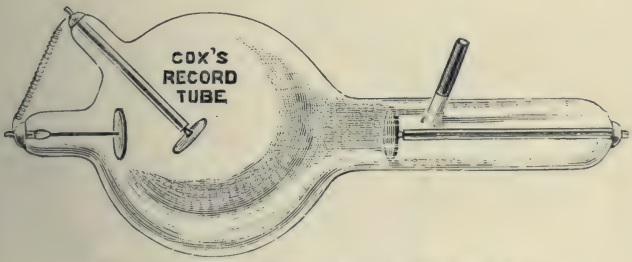

Fig. 15.—Focus Tube with Extra Anode.*

Other methods of reducing the resistance in a tube are either by heating some substance, previously enclosed in an annex, until it gives off vapour whereby the vacuum is lowered. Many tubes have been designed with some contrivance of this kind, one of the latest being the tube figured below (Fig. 17); or a method may be used which depends on the theory that the outer side of a focus tube in action becomes inductively charged with electricity, which acts upon the residual molecules inside the tube, holding them bound to the surface of the globe, and, as it were, removing them from circulation, so that the supply of molecules to keep up the bombardment from the kathode becomes deficient. To counteract this tendency, some observers have placed a sheath of tinfoil or a strip of damp cotton-wool round the kathodal end of the bulb, and others have replaced this by a ring of wire connected with the earth. By any of these devices a tube can be made to act as though of lower resistance. The higher the resistance of the tube the greater is the penetrating power of the *x*-rays given off, and the higher, too, must be the power of the coil necessary to set it in action.

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* This tube was awarded the gold medal in a competition by the Röntgen Society.

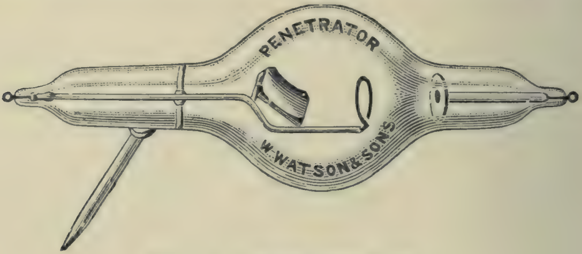

FIG. 16.—PENETRATOR TUBE.

The testing of a tube is managed in various ways. The ordinary rough plan is to examine a hand with a screen or fluoroscope. A more accurate test of penetration has been contrived under the name of the sciameter, and is based upon the principle of figures of metal viewed through graduated thicknesses of metallic foil by means of a fluorescent screen. One of the first was that of Messrs. Reynolds and Bransom, and among the later may be mentioned those of Max Kohl and Mr. K. Schall. The instrument is of value because good penetration is absolutely necessary to obtain photographs of deep structures, such as the pelvis or the skull, and by its use the quality of a tube can be determined before undertaking a long exposure.

The quality of a tube is subject to changes not only from week to week and day to day, but also while being worked even a few minutes. Each tube, as a matter of fact, has its own peculiarities.

To the worker with the Röntgen rays a really good tube is a priceless possession, to be cherished and protected in every way.

VI. THE FLUORESCENT SCREEN

The screen depends upon the property possessed by the Röntgen rays of causing fluorescence in certain bodies, such as the platino-cyanides of potassium and of barium, calcium tungstate, many uranium salts, and numerous other chemical compounds. The commercial screens are usually made with barium platino-cyanide, and are very finely spread with the powdered crystals by means of a special machine, and finally varnished. An absolutely smooth and even layer is essential for clear definition.

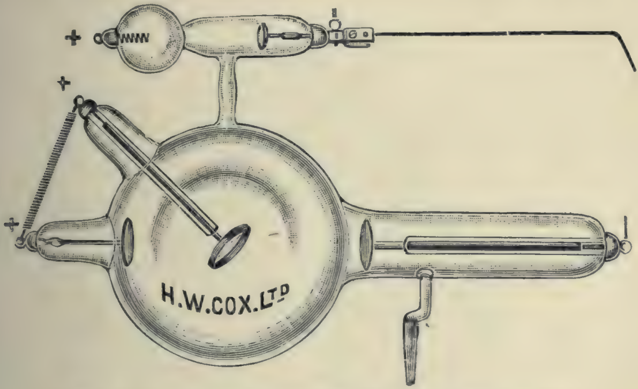

Fig. 17.—Record Tube (with Vacuum Regulator).

The light emitted by the fluorescent screen is not of a high order of brilliancy, and when using the screen it is necessary to have the room perfectly dark, to place a cloth over the break of the coil, and to enclose the Röntgen tube in a black paper wrapper. After remaining a few minutes in darkness the eye becomes very much more sensitive, and when difficult cases are to be examined a few minutes' rest in a dark room is a great help. The object to be examined is placed between the tube and the screen, the latter being held with the fluorescing surface on the side facing the operator. Various distortions are produced of the parts which are not in the plane of the screen, but a little practice enables them to be understood and allowed for. The screen, when not in use, should be kept away from dust and damp, and it is often advisable to protect it with a layer of celluloid or other transparent material, especially for campaigning purposes.

The value of the screen lies in its convenience when an immediate diagnosis is required. By means of the screen, too, a part of the body can be looked at from all sides, and in many cases the indications supplied by a screen examination are sufficient. By its means a diagnosis that would baffle an hour of careful ordinary examination might be laid bare in an instant by a glance through the fluoroscope. This promptness has commended the screen to the enthusiastic praise of the army surgeons who have used it in actual warfare. In hospital practice, too, the screen will suffice for a large proportion of cases in which coarse injuries of bones or joints are being investigated. The photographic method, however, has certain advantages which are of great value in difficult cases. For example, the action on the plate is a cumulative one, and thus, during exposure, it will collect and, when developed, will reveal a number of minute details which would escape notice in a screen examination. Moreover, the plate gives a permanent record, and allows of careful subsequent examination and of measurement.

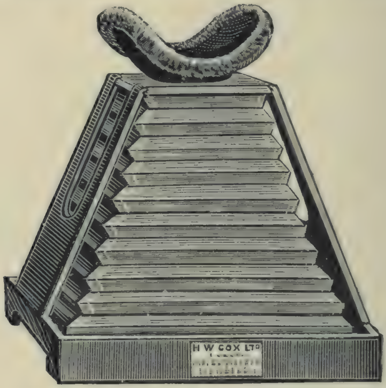

FIG. 18.—THE CRYPTOSCOPE.

The cryptoscope, or fluoroscope, is intended to do away with the necessity of a darkened room. It consists of a dark chamber, shaped like the body of a photographic camera. At one end is fixed the fluorescent screen, and at the other is an aperture through which the observer looks (see Fig. 18). The trouble of holding up the instrument, though apparently a small matter, is nevertheless enough to put this method at a disadvantage when compared with the use of a simple screen in a darkened room.

VII. PHOTOGRAPHY

A knowledge of photography is essential to the experimenter who wishes to carry out the whole process with his own hands. All the usual dry plates of good makers seem equally sensitive to the focus tube rays, but amongst them may be specially mentioned the Cadet Lightning, the Paget XXXXX, the Imperial Rapid, and the Lumière plates. With the last beautiful results may be obtained, at the cost, however, of a slow development. Many observers have found that slow plates are just as good in practice as extra rapid ones. For use the plates are taken from their boxes and transferred to opaque paper envelopes in a dark-room. It is better to enclose them in two layers of coloured paper—an inner one of orange and an outer of black. After exposure the plate, still in the envelope, is taken back for development to the dark-room. Where light-tight envelopes are used it is well to adopt a routine of placing the sensitive surface of the plate beneath the plain or ' address ' side of the envelope.

Developing solutions may be prepared of pyrogallic acid, hydroquinone, metol, and various other materials. If pyrogallic acid be selected, the following formula will be found to give good results with almost all kinds of dry plates. But in general the plate should be developed by the formula prescribed by the makers and sent out with the packets of plates.

Stock A.

Pyrogallic acid	1 oz.
Potash metabisulphite	2 drs. 10 grs.
Ammonium bromide	2 drs. 10 grs.

Water to 10 oz.

B.

Ammonia, strong solution ...	5 drs.

Water to 10 oz.

C.

Pyrogallic acid solution (Stock A) ... 2½ drs.
Water to 10 oz.

To develop a whole plate, take 2 oz. of C and 1 dr. of B, but do not mix them until quite ready to proceed with the development.

The developer may be divided into three solutions, of which one gives density (A), while the others act as accelerator (B) and restrainer (C).

A.

Pyrogallic acid	2½ drs.
Metabisulphite of soda	2½ drs.
Water	20 oz.

B.

Carbonate of soda (crystals)	3 oz.
Sulphite of soda	1 oz.
Water	20 oz.

C.

Potash bromide	1 oz.
Water	9 oz.

Mix equal parts of A and B, add a few drops of C.

Dishes—the lighter the better—will be required to suit the various sizes of plates. They may be made in the smaller sizes of ebonite or of xylonite, and in the larger of papier-maché or of earthenware. Having taken the exposed plate out of the envelopes, place it in the developing-dish, mix the developer, hold the dish slightly inclined from you, and pour the developing solution quickly along the upper edge of the plate, so as to cause it to flow rapidly over the whole surface. Keep the liquid moving during development. The image, if properly exposed, should show within a minute from the time of pouring on the developing solution. The more gradually it appears the better the result is likely to be. If, after two or three minutes, it still lacks detail, pour off the developer and add to it a little more of solution B, and once more flood the plate. In from five to ten minutes the picture should be fully developed. Practice alone will enable one to decide when this important part of the process has been effected, but the film should be darkened through to the glass. The plate must now be taken out, rinsed, and placed in the fixing solution, which consists of

Hyposulphite of soda	16 oz.
Water	80 oz.

In this it should remain until all traces of unaltered silver salts have disappeared. It may then be exposed to ordinary light, and should be washed in running water, if possible, for about an hour, and afterwards placed edgewise to drain and dry.

The methods of development are legion, and only one or two of those that have yielded the best results in x-ray work are described here. Most of the makers of dry plates and of sensitized paper print on the cover of the packets a formula which they have found to be suitable for developing. One drawback to the use of a 'pyrogallic' developer is the way in which it stains the hands. To avoid that inconvenience, such substances as rodinal and hydroquinone have been substituted by many photographers. Metol does not stain the hands, but it is apt to cause a troublesome soreness of the skin.

Good results can be obtained with hydroquinone, which is a slow developer. The image begins to appear in about four or five minutes, and development must be continued for half an hour or more—indeed, until the whole surface has become blackened. To secure detail slow development appears to be the rule, and the plate may be immersed in a weak solution of developer and placed upon a suitable 'rocking' stand for forty minutes or more, when the strength of the solution is gradually increased. Metol gives a dense black negative, and combined with hydroquinone is a favourite combination with many Röntgen photographers, and has been well spoken of in the following formula :

Metol	80 grs.
Hydroquinone	45 grs.
Sodium sulphite (crystals)	640 grs.
Sodium carbonate (crystals)	640 grs.

Water to 20 oz.

A good formula for metol is: Metol, 5 parts, dissolve in distilled water, 50 parts, and then add sulphite of soda (crystals), ½ part.

For many kinds of plate a rodinal solution is efficacious and convenient. The writer has found this developer give excellent results. One part of rodinal is used to 16 parts of water. The image quickly appears, but development must be continued until it has gained considerable density. In cases of over-exposure the solution may be further diluted; for under-exposure a few drops of the following solution should be added:

Water	1 oz.
Bromide of potassium	½ oz.

Good results have been reported by double development, first with hydroquinone, until the image shows a fair amount of density; the plate is then immersed in a rodinal solution, in which a further slow development brings out the more delicate details of the picture.

The operator will do well to master the capabilities of one set of plates and of one developing solution. To procure good results, every part of the process should be performed thoroughly.

Intensification of negatives is sometimes necessary to strengthen a faint image, especially in the case of deep tissues taken with a high-resistance or 'hard' tube. It is carried out by first washing the developed and fixed plate, and then immersing it in a solution of corrosive sublimate of a strength of 20 grains to the ounce of water, rendered soluble by the addition of an equal quantity of ammonium chloride. The negative is left in this solution until its whole surface turns light gray or white; it is then well washed, and blackened in a solution of strong ammonia—10 drops to the ounce of water. Negatives intensified in this way print slowly.

Reduction of an overdense negative may be effected by washing, and then placing in clean hyposulphite solution; to the latter is then added a few drops of the following solution:

Potassium ferricyanide	1 oz.

Water to 10 oz.

Reduction at once commences, and when sufficiently advanced the plate should be rapidly removed and washed.

Printing from Negatives

As soon as the plate is thoroughly dry, it may be placed in the printing-frame, with the film side inwards. On the latter is laid the sensitized paper, which is in turn fastened on with the wooden back. The frame is then exposed to the light (not direct sunlight unless very dense) until the picture appears in deep tones, a fact that may be ascertained by raising half of the back and looking at the paper. When the negatives are thin some workers advise printing through green glass. The print when taken out is placed in running water until all cloudiness of the water disappears. It is then put in a toning solution consisting of

Chloride of gold	20 grs.
Acetate of soda	1 oz.
Water	20 ozs.

One ounce of this stock solution should be added to 10 oz. of water for use. Keep the print constantly moving, so that the toning may be even; and when the required tone appears, take it out and wash, if possible in running water, for some time. Then immerse in the fixing solution, consisting of

Hyposulphite of soda	2 oz.
Water	20 oz.

and let it remain about ten minutes. Once more wash thoroughly and hang up to dry. It is advisable to carry out the washing and toning in subdued light. When dry, the print may be mounted. The kind of mount is a matter that will repay attention, as nothing sets off a photograph more effectively than a good mount.

A combined toning and fixing solution may be used, and, although results are hardly so satisfactory as those obtained by ordinary methods, yet, on the other hand, time is saved, and if the process of washing be carried out thoroughly, good enough prints are obtainable.

With regard to photography in relation to Röntgen work, it may be observed generally that the roughest negatives and prints often afford all the information needed by the surgeon or the physician; still, it is clearly desirable to have good results in photographs that are to be kept, and now and then detail is absolutely essential, as when small splashes of lead or fragments of necrosed bone are buried in deep tissues.

Time may be saved in various ways. Thus, the drying process may be accelerated by soaking the wet negative for a short time in one or two changes of methylated spirit or absolute alcohol. When dry, the negative may be put in the printing-frame, and a print taken on some form of bromide paper by a short exposure to artificial light. Such a print is developed in the ordinary way, washed, fixed, and dried. By this means the surgeon may be presented with a print within an hour. A print on any of the gelatine papers (P.O.P., etc.) is much improved by drying in contact with glass according to the plan usually prescribed. This process of 'burnishing' compresses the gelatine and strengthens the weaker parts of the print.

Röntgen photographs may also be taken direct on sensitized paper. The Eastman Co., Cadet, and others have produced *x*-ray paper which is used in exactly the same way as the dry plate. Although these papers are not so good as glass plates, their advantages are of such a kind that further improvement is much to be hoped for. In using paper or films instead of glass plates, the operator must take care to lay them flat; otherwise the image may be distorted in a remarkable way, and thus give rise to pictures that may entrap the unwary into all kinds of fallacious readings. A good plan is to place the sensitized paper between two sheets of stout pasteboard or to back it with a sheet of glass or metal.

In the Greek War many Röntgen photographs were taken direct as positive images on Eastman's special paper. In this way, although there is not the clear definition in the resulting photographic record as that obtained by the use of negatives, yet, on the other hand, there is a great saving in time and also in risks of the carriage of fragile glass plates, and the results are quite good enough for many subjects.

VIII. THE INTENSIFYING SCREEN

Various attempts were made in the early days to increase the photographic effects of the *x*-rays and to shorten the long exposures which were necessary for the taking of a photograph of the thicker parts of the body. With this object the 'intensifying screen' was devised. It consists of a fluorescent screen, the surface of which is placed in contact with the sensitive plate, which thus has the double action of the focus-tube rays and of the light rays emitted by the fluorescent screen. Two such screens have been used, one on each side of the plate. The material used for these screens is tungstate of calcium; but it has been found impossible altogether to avoid a mottled appearance or 'grain' which is produced upon the negative when these screens are used. In consequence of the improvement in coils and in tubes these screens are rarely used nowadays. At the same time, it should be noted that by the use of the intensifying screen the exposure may be much shortened, and in particular the use of an intensifying screen may enable a small coil with a longer exposure to penetrate deep structures, and to approach a large coil in efficiency.

Messrs. Watson supply a neat mahogany frame to hold a sensitive plate and intensifying screen.

IX. DEFINITION

Clearness of definition depends upon a number of conditions.

First, with regard to the tube: The best definition would obviously be given where the rays were emitted from a mathematical point, or from a minute area of surface, and this in turn will depend upon the relative position of the anti-kathode to the kathode, and the quality of their surfaces. If the former be fixed exactly in the focus of the bombardment coming from the kathode, it is sure to become overheated and perforated or detached from the support. These drawbacks may be to some extent avoided by using either a thick platinum plate or one of platinum backed with aluminium for the anti-kathode, but in general use the anti-kathode is deliberately placed a short distance away from the focus; this saves the platinum, but impairs the sharpness of the images a little. Osmium and iridium, especially the former, have been found useful for the anti-kathode, and Mr. Davidson has recommended the use of a bead of osmium centred upon a thick piece of aluminium. The osmium is able to withstand the concentrated bombardment without disintegration, but for various reasons has not come into general use, and has been abandoned by Mr. Davidson himself.

In the photography of thick parts of the body great difficulties are met with. The chief of these is due to want of definition, but distortion of the images must also be reckoned with. Instead of sharp images on the plate, one often finds only a vague blackening with little or no detail, a result due mainly to the phenomenon of diffusion and the action of secondary rays. The effect of diffusion is to blur the image, just as happens with ordinary light when an object is viewed through a turbid medium. Placing the tube at a long distance from the plate does not prevent diffusion or the effect of the secondary rays, although it lessens the effect of distortion. Professor Röntgen showed that bodies in general behave towards the rays as turbid media do to light; he also showed that secondary rays were produced by the effect of the rays themselves when they impinged upon solid bodies, and that even the air traversed by x-rays becomes a subsidiary source of other irregular x-rays which, though feeble, are sufficient to blacken a sensitive plate during a long exposure. Mr. Wimshurst has also shown that photographic blackening of sensitive plates occurs in the whole region of space round a tube in action, and that the effect can be noticed even in plates which are fully screened by dense masses of metal from any direct incidence of rays from the anti-kathode of the tube. A lead screen or diaphragm close to the tube has been tried as a means of sharpening definition, with an opening to allow a passage to the rays from the anti-kathode, while stopping all those emitted by the walls of the tube. But this does not, of course, do away with the diffusion of the rays in their passage through the object to act upon the plate. A dense backing of thick glass or of lead applied to the photographic plate, on its reverse side, has also been found of use in 'sharpening' x-ray pictures of deep-seated parts, acting probably by absorbing the radiations before they can set up any 'secondary' rays to fog the plate from the back. It is, perhaps, in radiograms of the pelvis that this defect becomes most obvious; it also shows when examining the thorax with the fluorescent screen. A coin, for instance, placed on the surface of the body next to the screen gives a clear, definite shadow; but if placed on the other side of the body, away from the screen, the shadow becomes lighter, and much less distinct than would be the case when compared with the shadow cast by an ordinary lamp. It has been stated that these diffusion effects are not so strong with a new tube as with one that has been worked for some time.

To test the definition of tubes, Mackenzie Davidson employs a small hand-frame with a network of fine wires crossing each other at right angles, and fixed about 1 centimetre apart. With a screen he views this frame, holding the frame and screen so that they receive the rays which are given off obliquely by the anti-kathode, *i.e.*, the rays near the edge of the hemisphere of fluorescence of the walls of the tube. If the *x*-rays come from a small point or focus on the anti-kathode, the shadows of the wires as seen on a fluorescent screen will all be sharp, but if the radiant source is larger than a small point they will show astigmatism by their shadows; in other words, the wires parallel with the nearest edge of the anode will cast dark shadows, while the cross-wires will cast blurred and ribbon-like shadows, or even be invisible altogether.* The test is severe, for in any tube the rays which will probably give the best definition will be those coming off perpendicularly to the anti-kathode, while the oblique rays used for testing are the worst.

Mr. Lynn Thomas has insisted upon the desirability of bringing the vertical rays from the tube exactly over a Colles or other fracture. This relative position he secures by means of a plumb-line. The tube is placed as usual, with its long axis parallel to the sensitive plate. An imaginary line is drawn from the anti-cathode at right angles to the long axis to a point on the wall of the tube. A silk thread attached to the end of a slender rod is brought close to that point, and its free end weighted with a split shot indicates the path of the vertical ray beneath which the fracture should be placed. This plumb-line is more accurate than the ordinary method of measuring by the eye (Fig. 19).

The distance of the tube from the plate and from the parts to be radiographed is an important question on account of 'distortion.' If possible, it is no doubt best to have the tube at a comparatively great distance, and give a longer exposure where distortion is to be reduced to a minimum.

Where there are bones in two different planes, the image of those nearest the lamp may tend to obscure those near the plate. If a picture of the latter is wanted without the former, it is a good plan to have the tube very close. For example, if a picture of the upper part of the spine be desired, the tube may be placed nearer the sternum than if a general view of the heart and lungs were wanted; the bones of the sternum nearest the tube will then be given indistinctly.

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* *Archives of the Roentgen Ray*, vol. iii., No. 4, p. 68.

It has been stated that some makes of photographic plate do not give so good a definition as others. If so, this may be due to some fluorescent effect excited in the glass plate or in the sensitive film, or it may be that these plates are more sensitive to the secondary rays than others. Some developers — or, perhaps, methods of development — are better than others. Long development in a weak solution is likely to bring out details more completely than a quick development with strong

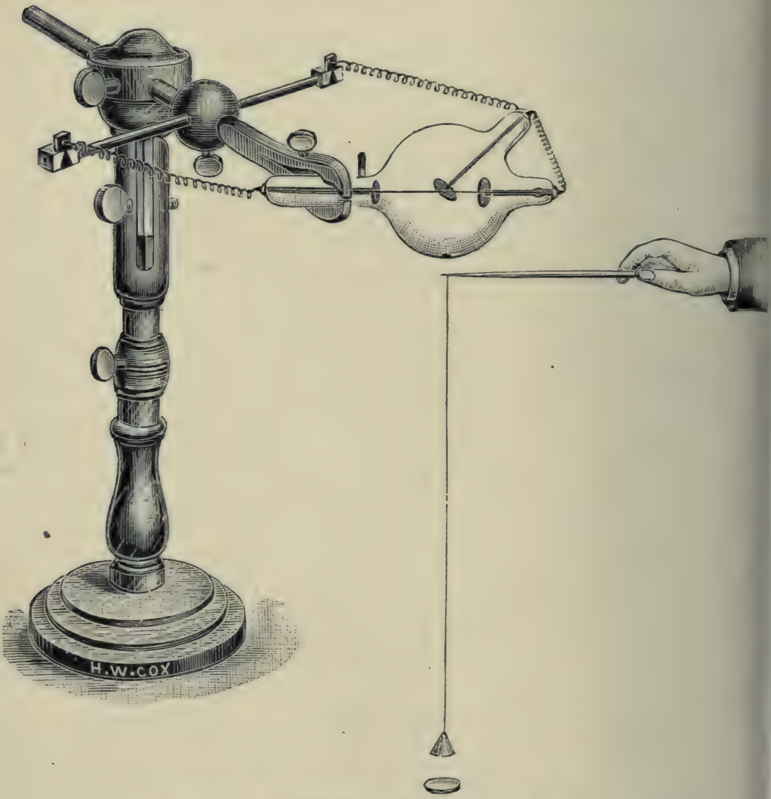

FIG. 19.—LYNN THOMAS'S PLUMB-LINE.

solutions. Some workers recommend a weak solution of rodinal (1 : 64) and water, and leave the plate in the developing bath for two or three hours.

Intensifying screens seem to improve the picture in some cases and to spoil the effect in others. The general impression is that they are of little value. They no doubt shorten the exposure, and bad definition may be due to over-exposure. Care should always be taken that the screen is kept close up to the sensitized film ; if not, misty patches will often appear here and there on different parts of the negative.

Movement on the part of the apparatus should be guarded against. If the tube is standing on the same table as the coil, and if the former be not very steady, the vibration of the contact-breaker may be quite sufficient to shake the tube, and perhaps cause the tube-holder to shift its position slightly. A similar disturbing effect may be produced on the plate and on the hand or arm of the patient if they are resting on the same table on which the coil is standing.

Movements on the part of the patient often produce hazy pictures, even where there are no defects in the apparatus. These movements may be voluntary or involuntary. The operator should always insist on the patient being in a suitable and comfortable position. When taking the hand, wrist, or elbow, the whole arm should rest on the table, and the patient sit back in the chair, especially when the elbow is concerned. The movement of the shoulder with respiration will cause a slight amount of indistinctness, and the clearest pictures of that part will be obtained when the patient is lying on a suitable couch. Pillows, cushions, and rugs may be placed under the parts not to be radiographed, but the board on which the plate rests should be as rigid as possible.

Involuntary nervous tremors will sometimes cause bad definition, especially in the case of children. If the patient feel cold, a couple of large silk squares may be thrown over the body without diminishing the radiographic effect.

With regard to the movements of the heart and lungs, radiograms of the thorax must always be more or less indistinct on this account. Clearer pictures of the thorax might possibly be obtained in some special cases if the patient could hold his breath for short intervals, during which the tube would be running, the current switched off for a few seconds during each fresh inspiration. To carry out this method in the case of the heart would be still more difficult.

X. STEREOSCOPIC RADIOGRAPHY

The important advantages to be obtained from taking two photographs and viewing them stereoscopically has been insisted on by Mr. Mackenzie Davidson.* His paper is so important that it is reproduced here with certain modifications.

'It is only necessary to look at two good stereoscopic radiographs in a Wheatstone's stereoscope to realize at once how thoroughly practical and important this method is in surgical work. A single skiagram is often confusing, if not misleading, but with two properly taken and viewed in a stereoscope the picture stands out in true relief, and shows clearly the relation of the parts.

'I will now describe the method and apparatus† I employ. It is that which up to the present time I have found to be the best.

1. The Crookes' Tube

'A tube giving the best possible definition, and at the same time allowing the shortest exposures is essential. The tube with an osmium anode (introduced by the writer) answers these requirements well.

'Two radiograms must be taken from two different points of view. After one has been taken, the Crookes' tube must be displaced and then another taken. I use the horizontal bar of my localizing apparatus as a support for the tube. Any desired displacement may be given to the tube; but it seems best to displace it about 6 centimetres, which may roughly be taken as the distance between our eyes. The two skiagrams thus taken from two different points of view, and the necessary marks made on the patient's skin to guide the surgeon, give data sufficient to localize the position of any foreign body, or other part, accurately by means of a localizer while the same skiagrams when viewed in the stereoscope give a picture enabling the surgeon to have a correct view of the parts in relief. This method, if correctly carried out, is so accurate and complete that the surgeon can have little cause for complaint.

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* *British Medical Journal*, December 3, 1898.

† The apparatus is made by Messrs. Muirhead and Co., Elmer's End.

'In order to insure that the two plates shall be in correct register, a changing-box is used. This consists of a frame over which is tightly stretched some calfskin. This is stout enough to support a considerable weight, and at the same time is thin and transparent to x-rays. The photographic plate, wrapped in black paper in the usual way, is placed beneath the skin, and supported against it by some suitable arrangement. Fig. 20 gives a view of the apparatus. The horizontal bar shows the tube-holder displaced to one side, and the clip on the right side is the limit to which it must be displaced for the second

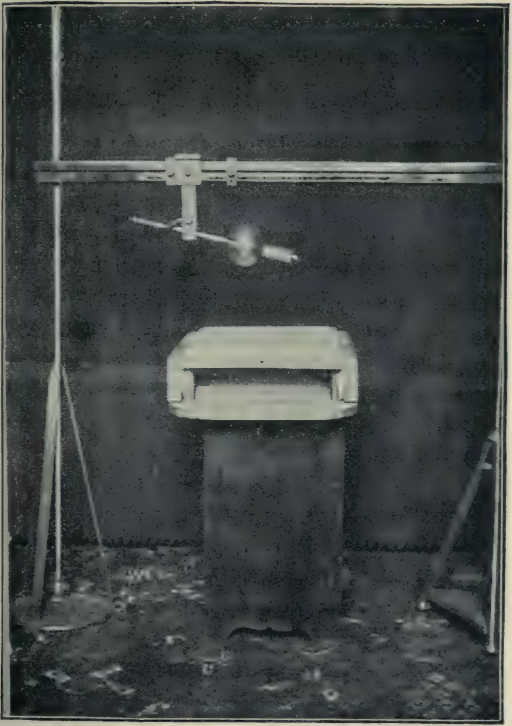

FIG. 20.—HORIZONTAL BAR WITH CROOKES' TUBE AND 'CHANGING BOX' ARRANGED FOR TAKING STEREOSCOPIC RADIOGRAPHS.

photograph. A wire is seen stretched on the nearer end of the box, and the bar is arranged parallel to this wire. This leaves a white line at the edge of each negative, and thus enables the photographs to be mounted correctly in register. A board is seen below, and upon it will be noted the photographic plate wrapped in the black paper. By means of a lever worked by a screw at the far end of the box, not visible in the illustration, this board is raised so that the plate is brought firmly up against the calfskin. The part of the patient to be skiagraphed is placed upon the top of the box. It will be easily seen how two photographs can be taken on different plates without disturbing the position of the patient; we are thus sure of obtaining correct stereoscopic pictures. This method can, of course, be carried out by having a table made with calfskin covering a space cut out of the top; or, again, an operating-table can have a window, so to speak, covered by the calfskin, upon which the patient can lie. This has the further advantage that it will allow a Crookes' tube to be placed below this part of the table, so that the patient could be examined by a fluorescent screen while lying on the couch.

2. Wheatstone's Stereoscope

'Two plane mirrors, about 6 inches square, are so fixed on a vertical support that their backs form an angle of 90° with each other. When the observer puts his face close to the edge where the mirrors meet, so that this edge lies vertically between his eyes, it follows that his right eye can see only what is reflected in the right mirror, while his left eye can only see what is reflected in the left mirror. Now, if the two skiagrams, taken as already described, are placed so that the right eye image is opposite the right mirror, and the left image opposite the left mirror, each eye will recognise its own picture, and they will combine, as usual, and give rise to a single image in perfect relief.

'There are several devices for supporting the skiagrams, and also for simultaneously making them approach or recede from the mirrors. The simplest of all arrangements is to have two mirrors mounted on an upright block of wood, which can be placed upon a table, while the skiagrams can be supported by any simple means in the proper position. The writer has devised a form of revolving Wheatstone stereoscope shown in Fig. 22.* A four-sided box, which can be revolved on a vertical rod, is placed opposite each mirror. Upon each of its four sides one of a pair of stereoscopic skiagrams is placed. The corresponding pictures are similarly placed on the other box. In this way the boxes can be rotated, and two corresponding skiagrams brought simultaneously in correct position opposite the mirrors. This prevents the necessity of adjusting each pair separately, and saves time in demonstrations. The block supporting the mirrors is attached to a small base with bevelled edges, which slides in a broad groove, and enables the observer to slide the mirrors towards or away from his eyes. In this way he can adjust the mirrors to the position which enables him to combine the pictures most comfortably. Each revolving box is fixed by its vertical support to its sliding board. This allows the distance of the skiagram from the mirrors to be altered at will.

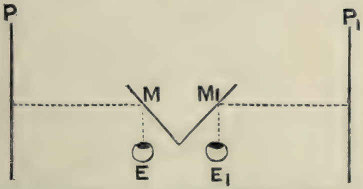

Fig. 21.—Diagram of Wheatstone's Stereoscope. (From Addyman's 'Practical X-Ray Work.')

'The Wheatstone stereoscope is peculiarly adapted for *x*-ray photographs—first, because, as everyone knows, a print from an *x*-ray negative is reversed; for example, if a skiagram of a right hand be taken, when printed it appears to be a left hand. Now, if such a print be viewed in a Wheatstone stereoscope, it is reflected in one of the mirrors, and is thus reversed to its original position by the reflection. Therefore, if opposite the right mirror is placed the print from the negative produced when the Crookes' tube was displaced to the right side, and opposite the left mirror the print from the negative taken when the tube was displaced to the left, the observer will then see the parts in correct stereoscopic relief, as if he had been looking at them with his eyes placed so that the right eye was at the point occupied by the anode when displaced to the right, and the left eye at the point occupied by the anode when the tube was displaced to the left. If the skiagrams be viewed under the same angle as they were taken, the stereoscopic picture would show the parts of the true or actual size, and the exaggerated distortion of the single x-ray photograph is overcome. The importance of such a result to a surgeon is great.

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* The Wheatstone stereoscope is made by Messrs. Curry and Paxton, Great Portland Street, W.

'There is no limit to the size of the pictures which can be seen in a Wheatstone stereoscope. The largest size the writer has as yet taken stereoscopically is 12 by 15 inches.

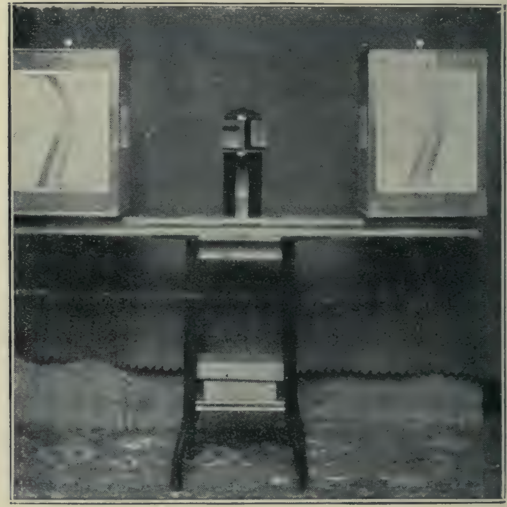

FIG. 22.—WHEATSTONE'S STEREOSCOPE.

'If the right picture be placed opposite to the left mirror, and the left picture opposite the right mirror, a stereoscopic picture will be seen as before, only reversed. For example, in one case a hand will appear as seen from the dorsal aspect; if the prints are transposed, it will appear as a hand seen from the palmar aspect. The same transposition can be effected by turning each print upside down.

'The negatives, when wet, can be seen in a stereoscope if they are held in proper position by upright frames, and each illuminated by a strong light diffused through ground glass or white paper, but the effect is not so good as viewing prints.

‘If it be desired to reproduce the radiograms as illustrations n a book or periodical, they can be reduced and mounted alongide of each other.

‘By practice it is not difficult to acquire the power of comining stereoscopic pictures without an instrument of any kind. There are two ways of doing this:

1. ‘By looking beyond the photograph, so that each eye sees he picture opposite it.

2. ‘The most easily acquired and most important for x-ray work, as it enables skiagrams of any size to be seen at once, consists in crossing the visual axes. This may be accomplished as follows: The photographs or radiograms are placed correctly in front of the observer; he then holds up his finger in the middle line between his eyes and the radiograms, and while looking at the top of his finger he will observe double images of each radiogram; by a little perseverance he will learn to make two of the images combine in the centre, and he will then have a beautifully clear stereoscopic image apparently in the air. Behind to the right and left will be two images, but these he soon learns to ignore, or he can cut them off by bringing his hands cautiously from the outer side of each eye towards the middle line, stopping the moment the two side-images are cut off. It is, of course,

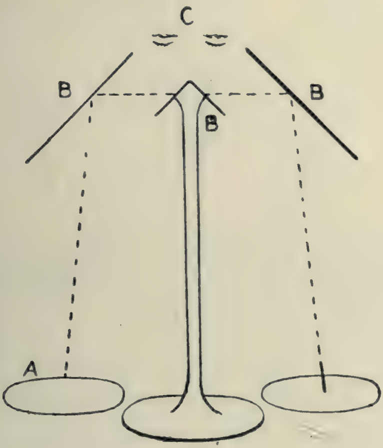

FIG. 23.—DIAGRAM OF MARIE'S STEREOSCOPE.

convenient in this way to see negatives in stereoscopic relief immediately after development.'*

Other forms of reflecting stereoscope may be used. A very convenient kind is one known in France as the stereoscope of Marie. In this the pictures to be viewed lie flat on the table below the mirrors, which are supported on a brass pillar. This disposition of the apparatus has certain advantages (Fig. 23).

Fig. 25† shows the method of obtaining Davidson's measurements for localization. It represents diagrammatically a photographic plate with an orientating mark (a) and the point of th localizing cross-wires x, x, which are registered in the patient' skin with aniline ink. The point b is the crux of the matter. I is secured by dropping localizing threads from the displacemer points of the tube on the horizontal bar above to the shadows the foreign body—let us say in this instance a small shot—on th plate below. The point where the threads cross represents th position of the shot, and a line drawn from the cross-threads pe

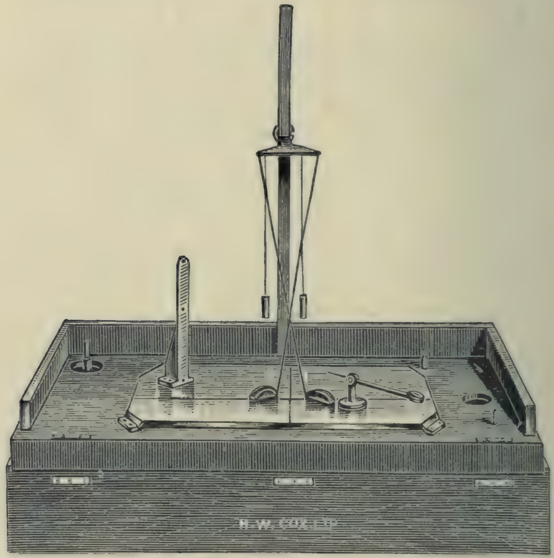

FIG. 24.—MACKENZIE DAVIDSON'S LOCALIZER (COX'S PATTERN).

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* See Wheatstone's papers already referred to and Leconte's "Sight" (tl International Scientific Series, Kegan Paul and Co.).

† For full explanation of Davidson's process, see p. 94.

pendicularly to the plate gives the point *b*. Two other measurements are necessary. In this case they are 2½ cm. and 1 cm. The shot will be found at a depth of 3 cm. from the surface at a spot which forms the point of an oblong figure, of which the sides measure 1 cm. and 2½ cm. respectively. Two sides of the oblong figure are already marked on the patient's skin, and the remaining two are added to the skin from the measurements obtained on the plate. The exact quadrant in which the foreign body lies is determined by the orientating mark *a*, which can also be registered on the patient's skin.

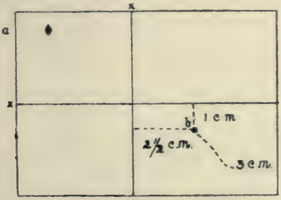

FIG. 25.—DIAGRAM OF LOCALIZATION.

XI. STANDS AND OTHER ACCESSORIES

Many good forms of tube-holder are in the market, and one is figured here. A wooden retort-stand serves for many kinds of exposures, but a heavy stand tall enough to rest on the floor is better than a little one on a table. The chief requisites are a firm base, easy joints, capable of tight fixing and of ready extension in every direction, and a long arm of non-conducting material, *e.g.*, hard wood. The stand is one of those details to which careful attention will be found essential to the production of good work. As the tube is hung from an arm supported only at one end, it is readily made tremulous by the amplification of any motion communicated to its support, and a shaky tube means a blurred photograph.

A simple operating-table can be made of a piece of board 6 feet long, 2 feet broad, and 1 inch thick, mounted on firm supports about 18 inches high. The coil and tube-stand can be placed on the floor, or on a second table close to the patient. By using the small mounted screen occasionally, it will be seen if the tube is emitting rays of good penetrating power—a simple precaution whereby much subsequent disappointment may at times be prevented. If the process can be conducted in a dark room, the ordinary screen will be available; but if it be in a lighted room,

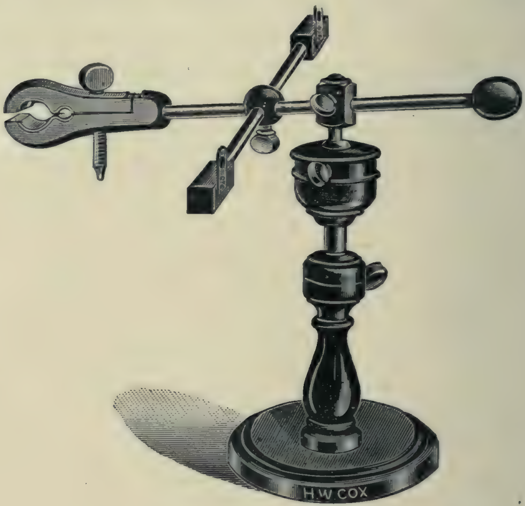

Fig. 26.—Tube-holder.

it is difficult for the inexperienced eye to determine whether the tube is at its best or not. In the latter case the fluoroscope,

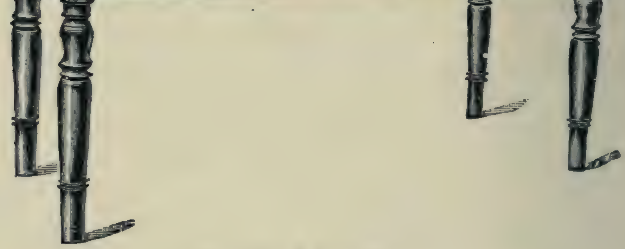

Fig. 27.—*X*-Ray Table.

which, as already explained, is simply a screen mounted in a stereoscopic camera, will be found of service.

An operating-table may be extemporized from an ordinary deal table without drawers, and in the latter case the screen can be used beneath the table-top. Numerous special couches have been constructed, many of them with canvas tops. The accompanying illustration (Fig. 27) shows a simple one of modern type, made by Watson and Sons.

Davidson has a useful combined x-ray couch and tube-holder which allows the tube to be shifted into any position along the length and breadth of the table. There is also a window (see above, in his account of stereoscopic radiography) fitted with a convenient sheepskin tympanum for screen observations and for stereoscopic or ordinary photography (Fig. 29).

The ends of the table should have hinged flaps, so that the patient may lie in a reclining position when required.

Fig. 28 gives an idea of the essentials of a compact outfit for field work. The apparatus is arranged so as to take to pieces and to pack in small compass.

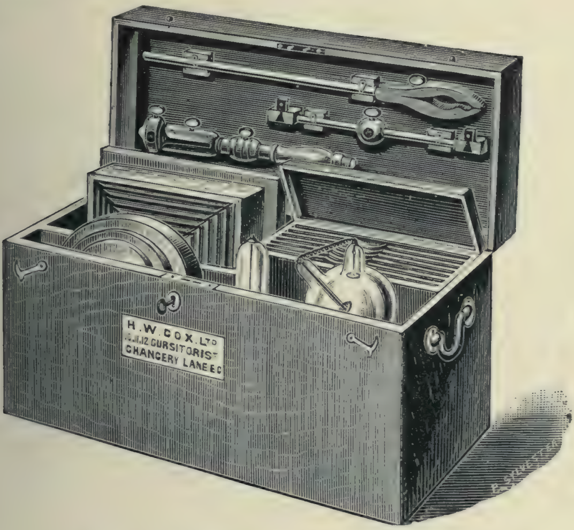

Fig. 28.—Portable Outfit for Field Work.

XII. PRACTICAL APPLICATION OF THE RAYS

The proper management of Röntgen ray work involves attention to a number of details. It can be acquired only by a careful study of the various parts of the apparatus, and also by long practice; unless these be mastered, the operator may produce nothing but poor results, and may speedily ruin the best and most costly coil. In the following description an attempt has been made to describe the process in a systematic manner, much as it would be carried out in actual practice.

First examine the platinum points of the contact-breaker; see they are perfectly smooth and even, also notice that the arm of the switch which passes the current into the 'primary' of the coil is in the 'off' position. If the condenser be connected to the coil by means of wires fastened to binding screws on the base of the coil, see that the wires are firmly screwed down. Place the discharging-points of the coil opposite each other, about ½ inch apart.

The battery having been tested, one end of a piece of thick well-insulated copper wire should be firmly fixed in the positive terminal of the battery, and the other end securely fastened to the binding screw on the coil; a second piece of wire should be similarly fixed on the negative terminal of the battery, and led to the other binding screw on the coil. Examine all the connections of your battery, and see that the ends of the wires are clean and firmly screwed down.

Now turn the handle of your switch to the horizontal or 'on' position, and bring the platinum points gently together by means of the regulating screw attached to the contact break. The hammer will begin to vibrate, and sparks will at once commence to pass between the discharging-points; withdraw these to see whether sparks still pass when the distance between them is sufficient for the excitation of the tube to be used. If necessary, increase the pressure at the platinum points by means of the tension screw until the spark passing between the discharging points is of the proper length. The battery and coil are now in working order and ready for use. Turn off the current by means of the switch. The latter should move stiffly, otherwise it is liable to fall and set the coil in operation at a moment when unpleasant, if not serious, results might follow—that is to say, by communicating a shock to the operator or to any other person who might be in contact with some part of the circuit. Two pieces of fine gutta-percha-covered copper wire should now be fastened to the supports of the discharging-rods, one end to each, and the two ends to the terminals on the focus tube. It is important that the direction of the current between the discharging-points should be recognised. If when the switch is turned on the tube shows an even hemisphere of green fluorescence on the side facing the front of the anti-kathode, then the current is in the right direction; but if the green light is patchy and irregular the direction is wrong. In the latter case reverse the switch, and at once the space between the anode and kathode should glow with the characteristic apple-green colour. By the use of the screen all doubt may be set at rest; with right direction it will fluoresce brightly, and the flesh of the hand placed behind the screen will be easily penetrated, and show the shadow of the bones distinctly; with wrong direction scarcely any Röntgen rays are produced, so that only a feeble fluorescence of the screen can be perceived. Having once found the right direction, make a

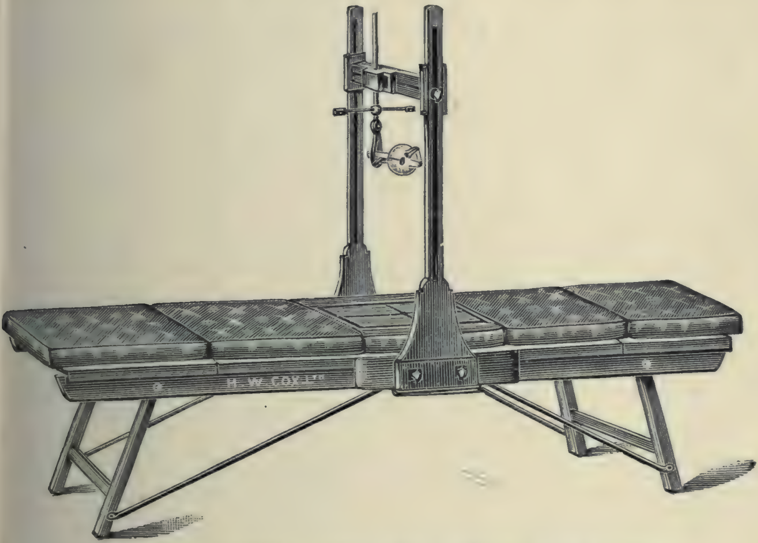

Fig. 29.—Davidson's Couch, with Shifting Tube-holder.

note of the binding screw of the coil to which the + of the battery is fastened, and also the direction of the handle of the switch. Change the wires of your battery to the opposite binding screws, and you alter the direction of the current; change the direction of the switch-handle to the opposite side, and you alter the direction of the current; change both the direction of the wires and the switch-handle, and the current flows in the same direction. Many coils work best with one position of the primary connections.

Take care that the wires leading from the coil to the focus tube are not so near each other at any part of their course that the spark will pass between them, instead of through the tube. Caution is also required to avoid shocks, both from the coil and from the wires leading to the tube. The golden rule for the operator is, never to touch any part of the apparatus while the current is 'on.' If any readjustment be required, switch off the current first, and then make the required alteration. The current from a single wire may give a smart shock without causing any serious results, but if the body form a part of the secondary circuit, by contact with both wires at the same time, the consequences might be of an alarming nature. Too great care, therefore, cannot be taken to prevent the current entering the body either of the operator or of his patient; the longer the spark used, the greater are the precautions necessary. The focus tube should be fastened firmly in the insulated holder so that the front face of the platinum anode lies parallel to the photographic plate or screen. If the platinum get red-hot, the current used is too powerful, and should be lessened by reducing the pressure between the platinum points by means of the regulating screw. The tube is in the best working condition when the upper surface of the platinum is covered with a green velvety glow, and the under surface shows just a faint redness.

The distance of the tube from the object to be photographed is important. For objects not more than an inch thick, a foot is a good distance, but for the thicker parts of the human body from 20 to 30 inches is desirable. The length of the exposure will vary according to the distance, the penetrating power of the tube, and the thickness and opacity of the object. With a tube exhausted to work with a 4-inch spark and placed 1 foot from the plate, a good photograph of the hand of an adult should be obtained with an exposure of less than half a minute. It need scarcely be urged upon the beginner that he should become thoroughly acquainted with the apparatus and the methods by which the best results are to be obtained before taking photographs of patients. He will find in his own person a convenient subject for experiment. When he has succeeded in taking every part of his own body, he will be prepared for the ordinary difficulties of Röntgen ray photography.

If the plate be not already placed in the protecting envelopes, it will be necessary to go to the dark-room to do so. The film should be placed towards the address side of the envelope. It may be recognised in the dark-room by its dull, non-reflecting surface, whereas the plain-glass side shines, and reflects light sharply. Do not bring more plates than the one to be used into the operating-room, as they would in all probability be affected by the Röntgen rays, even if standing a long way from the tube. They may, however, be kept in the same room if shielded in a box of thick metal.

In the application of the rays to the teeth, special means must be taken to meet the requirements of the case. As the sensitized surface must be placed in the mouth, glass is almost out of the question. A good celluloid film should be chosen, and cut in pieces about 1 inch by ½ inch. The latter may then be wrapped in black paper, and the whole fastened up securely in thin rubber,* so as to keep out all moisture while in the mouth. The tongue should be pressed firmly against the rubber in order to keep the plate close to the teeth. The patient should, of course, be placed in a comfortable position, yet so that it is impossible for the head to move during the operation. An exposure of five minutes or more will be required to get good detail. The tube should be placed not less than 12 inches from the face. For the sake of precaution, the hair can be shielded by means of a thin sheet of lead held in a clamp and placed a few inches from the head. After exposure, the plates are developed in the usual way.

It is obvious that the value of the Röntgen results can be best appreciated by the skilled anatomist. Yet even to him this new method of investigation presents many difficulties. As a rule, he is not an expert in practical photography. Every stage of that process is liable to produce spots and blurs which may mislead, but which are reduced to a minimum in the hands of a good photographer. Hence it is a distinct advantage, where possible, to leave the development of the exposed plates to such skilled hands. The professional photographer, however, will also require some special experience in order to obtain the best results, for the development of a portrait or of a landscape differs widely from that of a Röntgen ray negative. Much depends upon knowing what ought to appear upon a plate; that which at first seemed a failure may, if properly handled, prove a great success. Then, of course, it must be borne in mind that the surface of the object or subject close to the plate receives the sharpest definition, and is nearest its natural size, while the farther the parts are from the plate, the more exaggerated and the more indefinite the record that is obtained.

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* The rubber may be fixed on by a few turns of ordinary sewing cotton.

Whatever kind of contact break is used with the coil for the purpose of taking a photograph, a rapid one is needful for screen work; otherwise the flickering light produced renders it impossible to obtain any useful or trustworthy information. A highly-exhausted tube should be selected and fastened in the stand, with the platinum anode facing the observer. All light should be excluded from the room, the tube itself covered with black paper, and a dark cloth placed over the contact break. The subject or object to be examined should be placed as near the tube as possible—not more than an inch away from it. As on the sensitive film the parts nearest the plate are most sharply defined, so with the screen. If it be necessary to examine the sternum, the tube should be placed at the back, and the screen on the front of the body, with the fluorescing material towards the eye. At first nothing appears distinctly on the screen, but after a time, as the eye grows accustomed to the feeble vibrations caused by the fluorescing surface, it also begins to distinguish the strong and sharp shadows of opaque objects nearest the screen. It is practically useless to go direct from strong sunlight to the examination of any fairly thick object like the human body. The eye of the observer, about a foot away from the screen, should take first a general and afterwards a more specific view. Every bone and every articulation should be systematically examined, commencing with the thinner members, such as the hand and arm, the foot and leg. Needles may be fixed in the arm in various directions, both on the side near the screen and on the opposite side, so that an idea may be formed of their relative appearance.

The thorax should next be explored. With the screen on the front of the body, the shadow of the heart is distinctly seen, its pulsations may be counted, and anything abnormal in its position noted. The cavities of the lungs appear bright, and the respiratory rise and fall of the diaphragm are conspicuous. The dark shadows cast by the liver and spleen are plainly outlined in the abdomen, but, curiously, the convolutions of the adult intestines furnish no readable record by the Röntgen rays. The pelvic cavity, although more easily examined than the abdominal, still presents a limited field. To examine it, the tube should be placed either between the ilium and the dorsal vertebræ or below the sacrum. As in astronomical photography the sensitized plate reveals thousands of stars invisible through the telescope to the eye, so, too, the eye fails to perceive on the screen many interesting and important points that are distinctly photographed on the plate. With our present knowledge and apparatus, the screen is useful in the examination of most fractures, both before and after 'setting,' also for detecting and localizing any foreign opaque substance in those parts of the body which the Röntgen rays can readily penetrate. The screen also aids our investigation of the organs contained in the thoracic cavity.

To deal successfully with a large number of photographic plates and photographs it is clear that order and method are desirable. Plates may be packed in boxes sold for the purpose, with an index of contents. Photographs should be carefully preserved in portfolios and dust-proof drawers. A systematic record of all the essential facts of each Röntgen ray exposure may be kept by means of Dr. Walsh's charts.* These are bound in books, and will be found to afford a most convenient plan of taking rapid and accurate notes where much work is done. In some hospitals these charts have been used exclusively and bound into volumes; they form a valuable uniform means of reference. They have been found in some instances of service in the South African War.

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* Published by Baillière, Tindall and Cox, Henrietta Street, London, W.C.

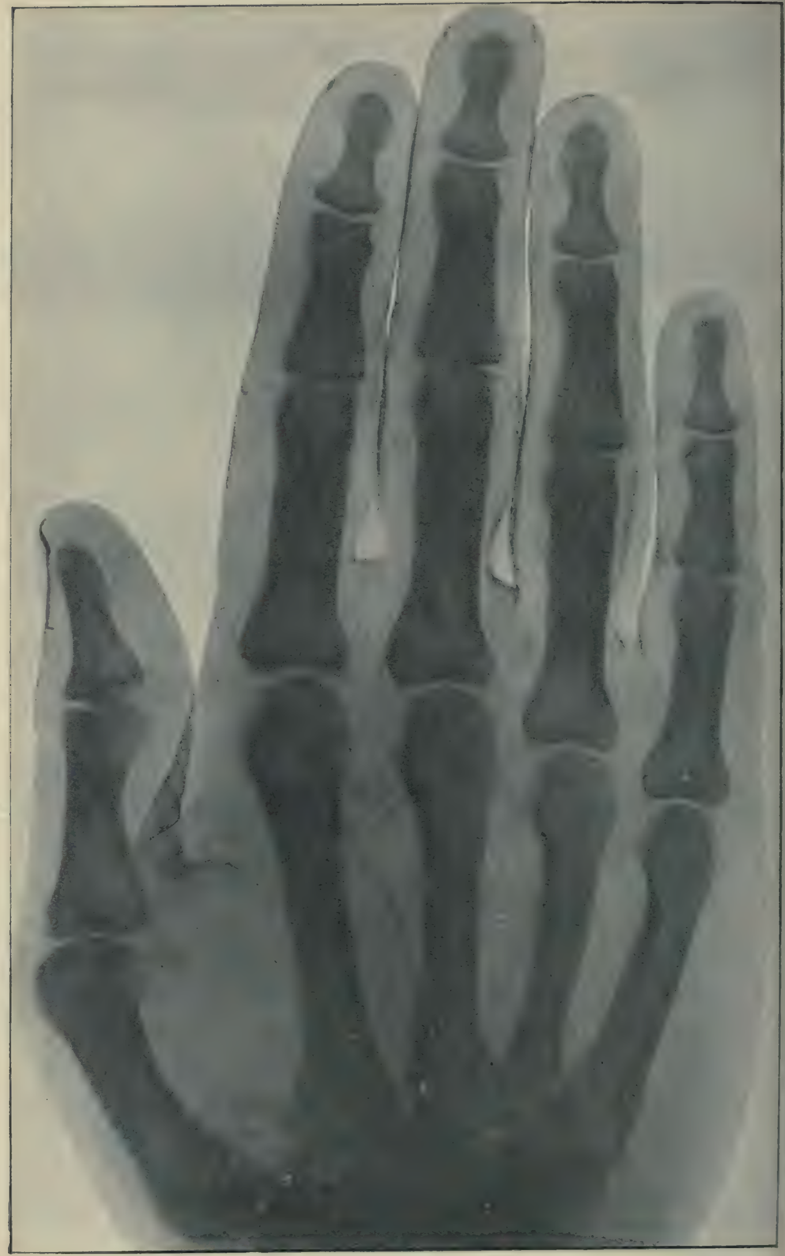

Fig. 30.—Hand showing Skin-markings.
Dr. Walsh's Method. [*To face Part II.*

PART II

MEDICAL AND SURGICAL APPLICATIONS

The advantages of Röntgen ray work to the medical man are not confined to purely clinical purposes, but are here and there extended to other branches of professional study, such as forensic medicine, anatomy, and physiology.

In order to deal with the subject systematically, it may be split up into various sections. The following rough classification will be found to cover most of the ground broken by this modern means of accurate investigation :

A. Surgery.
    I. Foreign Bodies.
    II. Bones :
        (*a*) General Remarks.
        (*b*) Fractures and Dislocations.
        (*c*) Separation of Epiphyses.
        (*d*) Congenital and other Bony Deformities.
        (*e*) Diseases of Bone.
        (*f*) Other Surgical Points.
        (*g*) Action of Rays upon Micro-organisms.
    III. Mapping of Skin Surfaces.
B. Dental Surgery.
C. Nasal and Throat Surgery.
D. Medicine.
    IV. Regional.
        (*a*) Thorax and Abdomen.
        (*b*) Heart and Great Vessels : Aneurism, Cardiac Enlargement, etc.

- (*c*) Lungs and Lung Diseases: Pleurisy, Phthisis, etc.
- (*d*) Abdomen.

V. Other Medical Points.

VI. Action on Skin and Deeper Structures.

VII. Therapeutics.

E. Obstetrics and Gynæcology.

F. Legal Medicine.

G. Anatomy.

H. Physiology.

I. Veterinary Uses.

A. SURGERY

When the first Röntgen photographs were published, scientific surgeons all over the world became keenly alive to the possibilities of the situation. So far, they have gained the lion's share of practical help from the new science, but the process has also proved of great and increasing value to the physician. As methods improve, they will both assuredly derive a still greater amount of precise and valuable information from the same source. Their future success, however, will most likely depend upon the definition not so much of substances that are relatively opaque to the rays, but rather of the more translucent structures, such as soft tumours, gall-stones, abscess cavities, internal organs, and so on. So long ago as February, 1896, Adolph and Leng recorded the fact that they had obtained a Röntgen ray picture of ordinary connective tissue.

I. FOREIGN BODIES

In nothing have the Röntgen methods proved of more immediate practical use to the surgeon than in the finding of foreign bodies. The nature of the embedded substance is of importance, for, in order to yield a readable record, it should offer a resistance to the rays considerably greater than that of the tissues in which it lies. Thus, a bullet buried in translucent muscle would cast a deep and clear-cut shadow on the sensitive plate or screen, whereas it would be obscure if lodged in more opaque structures. Fragments of glass can be readily photographed, because they resist the rays, but such penetrable materials as leather, clothing, paper wads, and wood cannot, as a rule, be demonstrated by radiography.

All surgeons know that at times it is impossible by any ordinary method to detect the presence of a foreign body in the deeper tissues. A familiar instance of this uncertainty is met with in the palm, where a fragment of needle may elude not only careful and skilful manipulation, but an extensive cutting operation as well. The help that can be given by the Röntgen rays under kindred circumstances may be judged from the following cases that have been brought under the writer's notice:

A lady, who some time previously ran a needle into her hand, had her palm explored by a surgeon, with negative results. A little later a radiogram, taken through splint and dressings, revealed a piece of broken needle lying in the first interosseous space, close to the distal end of the thumb metacarpal. From the information thus obtained the foreign body was readily removed by a second operation. In other words, the process furnished the surgeon with a method of diagnosis which denoted not only the presence, but also the shape, nature, and position of the body to be removed.

In another case a child suffered for several weeks from a swollen foot, for which no cause could be ascertained. A radiogram, however, showed fixed in the astragalus a broken needle, the removal of which was followed by speedy recovery.

These facts suggest a useful application of the Röntgen rays—namely, to locate a hypodermic needle broken off beneath the skin. As everyone knows, such an accident may be caused by an abrupt movement on the part of the patient. Further, the fragment is apt to wander about freely, so that few surgeons would feel justified in undertaking a cutting operation unless the foreign body could be fairly well localized. The danger to the host of a wandering object of the kind in the tissues is obvious. Suppose it to be small and buried, say, beneath periosteum or in the sheath of a tendon, it would almost certainly elude the exploring finger of the surgeon, unless he be guided by the exact information now available in all cases by means of a localizing Röntgen photograph.

The opacity of glass* to the rays, probably due to the contained lead and other metals, makes it easy to detect fragments buried in the soft tissues. It is, of course, well known that such objects may remain embedded for many years, and often give no sign of their presence beyond some slight enlargement and pain or discomfort on deep pressure. By the Röntgen method, however, a foreign body of that sort may be so exactly defined that the surgeon can cut down upon and remove it without a moment's hesitation. After any injury of the kind, indeed, it would be well as a routine practice to examine by the rays, in order to ascertain whether any glass has been left in the wound. In the next case negative evidence was obtained as to the presence of glass, but positive testimony as to joint mischief.

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* Potash glass is more translucent to the Röntgen rays than lead glass.

A. B——, a milliner, admitted to the Metropolitan Hospital with the following history. Two months previously her little boy, whom she was nursing, by a sudden kick broke a wineglass in her hand. The left forefinger was cut, and severe pain followed, reaching up the arm to the shoulder. A piece of glass was supposed to be in the wound, which had been explored before the patient came to the hospital. On admission the wound was found to be cicatrized, and the end-joint of the finger stiff. The accompanying radiogram (Fig. 31) proved the absence of glass, but disclosed various changes in the joint. Absorption of the distal end of the second phalanx had taken place, and fibrous anchylosis was diagnosed from (*a*) the appearance on the photograph of a faint line between the phalanges, and (*b*) the clinical condition of the joint.

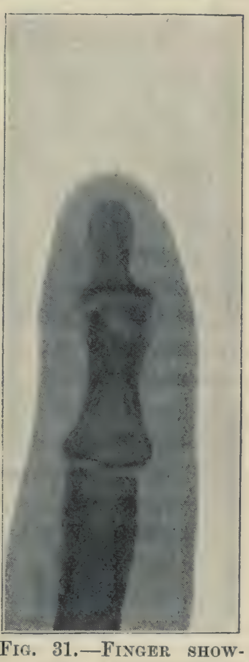

FIG. 31.—FINGER SHOWING ABSORPTION OF BONE AND FIBROUS ANCHYLOSIS.

Lead is exceedingly opaque to the rays, and hence the new method does yeoman's service in gunshot wounds. The erratic course taken by bullets after entering the body often renders their discovery, under the conditions of ordinary surgery, a matter of impossibility. By means of a Röntgen ray examination, however, the surgeon may in many cases acquaint himself as to the exact whereabouts of the missile, and that without undressing the patient and without taking off splints and dressings. In that event, moreover, the shock entailed by prolonged manipulation will be avoided. The Röntgen method may also be of service in this class of wounds by proving the absence of a bullet. In doubtful cases the value of such negative evidence, both to the surgeon and to the patient, is so obvious that it need not be enlarged upon.

The difficulty of gaining exact evidence as to the presence of a rifle-bullet was well illustrated in the classical case of Garibaldi. Day after day his medical attendants, surgeons of European fame, endeavoured in vain to find out whether a ball was or was not embedded in the ankle of their illustrious patient. At length Nélaton settled the point by means of the ingenious probe that bears his name, an instrument tipped with porcelain, on which the leaden bullet traced an unmistakable billet. Röntgen, however, has far surpassed Nélaton's plan as regards ease, certainty, and simplicity. Had this method been available in the case of Garibaldi, a few minutes' exposure would have sufficed to clear up the diagnosis. A similar localization might possibly have saved the life of the late United States President, Garfield. It is interesting to add that in 1896 the presence of a Japanese bullet in the head of the distinguished Chinaman, Li Hung Chang, was demonstrated by the Röntgen rays during his visit to Europe.

Military Surgery

In military surgery the Röntgen processes have proved of grea value. On a campaign, where baggage is naturally cut down t the last ounce, some difficulty is presented by the cumbersom nature of the necessary apparatus. However, the electrica engineers have already to a great extent met the wants of th case. As it is, an ordinary field ambulance waggon may b calculated to carry a ton burden, a weight that would more tha accommodate an x-ray installation with dark-room and photographic requisites. In the British army the Engineers alread possess a photographic waggon, which might be adapted to suc work. However, the Röntgen apparatus would not as a ru be located in the front, but at a base hospital, where bulkines would not be so positive a hindrance.

Hitherto the chief appliances for detecting deeply-place bullets have been based on (*a*) simple and (*b*) electrical contac and the former, the two best are Lecomte's *stylet-pince*, made to bite away a morsel of the metal, and Nélaton's probe, which, as already stated, is marked by the lead. Electric probes, on the other hand, are constructed to show, by means of bell, galvanometer, or microphone, when the circuit is completed by a bullet touching the end of the probe. The two first-mentioned instruments, however, are useless when dealing with modern hard-mantled projectiles: the stylet-pince fails to bite, and Nélaton's probe to indicate the latter-day small-bore ball with its steel or cupro-nickel envelope. Clearly, no such difficulty awaits the method of Röntgen diagnosis, which will at once demonstrate, not only the position, but also the exact size and shape of a missile in any part of the body.

The first opportunity of the trial of the new discovery in actual warfare was afforded by the Græco-Turkish war. The *Daily Chronicle* sent off a complete outfit to the seat of the war in connection with its national fund for the wounded.

Surgeon-Major Beevor carried out the Röntgen methods successfully on the Indian frontier during the Chitral campaign in 1898. His work was often carried on in a temperature that registered 22° of frost and over. The only damage to his coil was on a train journey in Central India, when the insulating wax melted out owing to the intense heat. He was able to repair the damage, however, and after that wrapped the coil in damp blankets. He found that the method was valuable in many surgical conditions other than the presence of a foreign body, as, for instance, in abscess, necrosis, undetected partial fractures, and injury to internal organs. In one case the spleen was penetrated. In another a round bullet passed at low velocity through the liver (driven by poor native powder): but the missile did not injure the plexus of nerves and vessels through which it passed across the body to a position between the ninth and tenth ribs, where it was located by the rays. This diagnosis could not have been attained by probing or other ordinary surgical procedures.

In the brilliant campaign brought to a close at the latter end of 1898 by the Sirdar, now Lord Kitchener, the value of the Röntgen methods was demonstrated under different climatic circumstances. In the face of great difficulties Major Beevor, R.A.M.C., applied them in the cold and mountainous districts of Northern India, whereas Major Battersby, R.A.M.C., in the Nile expedition encountered the not less trying conditions of storms and tropical heat. The latter distinguished officer, who was in charge of the Röntgen ray apparatus in the Soudan, related his experiences in a graphic manner in a paper read before the Röntgen Society of London, January 10, 1899.* The chief points raised may be thus summarised :—

First of all, it may be noted that the work was carried out in a climate where the temperature varied from 100° to 120° F. The destructive effect of that degree of heat upon insulating materials, upon fluids of batteries, and upon the processes of photography, may be readily imagined.

Between Wady Halfa and Abadieh the Soudan outfit had to travel for two days and a night in an open truck, exposed during the daytime to the fierce heat of a blazing sun. By keeping the casing of felt wet, however, the journey's end was reached without mishap, and a thermometric observation showed that the temperature in the interior of the coil did not exceed 85° F.

It may also be noted that Battersby is clearly of opinion that the more perfect appliances for war purposes will dispense with batteries and coils. ‘An ideal apparatus,’ he writes, ‘would consist of a statical or friction machine—some modification, for instance, of Mr. Wimshurst's, by which the focus tube could be excited directly. For such a design many physical difficulties confront us, but they are not insurmountable.”

Portability must always be a first essential in field work. So far as the coils were concerned, Battersby had one constructed in two parts, so that they could be slung one on each side of a mule or a camel. Each portion was packed in a teak box—the coil in one, and in the other condenser, commutator, break, and stand. These boxes were cased in thick felt, and also those containing the storage batteries, so that they could be constantly wetted, and their interior temperature thereby reduced by evaporation.

The generation of electricity was managed in a highly ingenious way, which may be described in Battersby's own words: ‘The pulley of a small dynamo is connected by means of a lea strap with the back-wheel of a specially constructed tan bicycle. The required velocity for the dynamo is thus obtai and our procedure is as follows: Having carefully adjusted circuit with the storage battery, and also with the voltm and ammeter, my warrant officer took his position on the seat of the bicycle and commenced pedalling. When 15 volts and 4 ampères were registered, the switch close to the handle of the bicycle was opened, and charging of the battery commenced. As the resistance became greater, a sensation of riding uphill was experienced, and the services of an additional orderly were requisitioned for the front-seat. This bicycle practice was generally carried out in a shade temperature of 110° F., so that at the end of half an hour we unanimously agreed that some other form of scientific amusement was desirable. Then the switch having been turned off before pedalling ceased, in order to avoid any discharge from the battery, the machine was brought to a standstill.

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* See *Archives of the Röntgen Ray*, February, 1899.

'Our cells were the ordinary E.P.S. cells, 40 ampère hour type, with a voltage of 2 volts per cell, and discharge of 4 to 6 ampères. The cells while being charged required the dynamo to give a current of 15 volts and 6 ampères; this multiplied together gives an electro-motive force of 90 watts, and as 760 watts equal 1 electric horse-power, $\frac{1}{8}$ horse-power was necessary to drive the dynamo for charging. It was also necessary to have an extra $\frac{1}{8}$ horse-power to overcome the resistance of the working parts and the opposing force contained in the full batteries, hence the necessity of tandem seat for extra man.'

Primary batteries are for various reasons unsuitable for military purposes. The small dynamo above alluded to was readily transported by rail and river, but was unsuited for carriage by mule, camel, or by bearers. One of the 10-inch coils and its accessories packed in an oak box was found too heavy for mule or camel transport, but when slung by ropes on a long pole could be carried, like an Indian dhoolie, on the shoulders of four men. Beevor advocates bearers above all other means of transport.

The insulated wire for the various parts of the apparatus should be specially made to withstand hot climates.

e tubes were ordinary bianodic focus tubes. Their platinum nals were protected at the ends of the tubes by a thick e of indiarubber. Each tube was wrapped in cotton-wool packed in a small wooden box, which appears to have ed safe transit.

e fluorescent screen was most useful at night, but unsatisfactory during the day, owing to the intense glare of the sunlight. Its surface was protected by celluloid, a most necessary precaution in a hot and dusty climate. This appliance is looked upon by Major Battersby as of surpassing importance in military surgery, where rapid diagnosis is everything.

Battersby used glass plates to the exclusion of celluloid films and sensitized paper. Those plates that had the thinnest film were most suitable for the intense heat, and an alum-bath was essential in all cases. The water available for developing was comparatively hot, and no ice was to be got, so that the more delicate shades of development had to be sacrificed. The developers used were rodinal, hydroquinine, metol, and "pyro." There was a marked tendency for development to proceed at a very rapid pace, often making the picture flash up at once. As a rule, this part of the work was done at three in the morning, that being the coolest part of the day.

After the Battle of Omdurman 121 wounded British officers, non-commissioned officers, and men were brought to Abadieh. Of that number there were 21 cases that could not be diagnosed accurately by ordinary surgical means, and of these the presence or absence of a bullet was proved by the Röntgen rays in 20 instances. The odd case was that of a shot in the lung, so severe that it was not considered justifiable to examine at the time. The focus tube was used about sixty times in all.

Spent bullet wounds are of common occurrence in fighting with natives whose powder is not of very good quality. In former days it was difficult to ascertain whether a bullet had lodged in such a wound or not, and consequently a good deal of probing was resorted to. All that is now changed, as shown by several of Battersby's cases. In one of the latter a private had gunshot wounds on the outer and the inner side of the left arm, and a third near the lower angle of the shoulder-blade. Three pieces of lead were shown by the rays at the outer side of the humerus. No bullet was seen in the chest, the wound in which was consequently not probed. Another soldier was shot near the tip of the right shoulder behind the acromion. The bullet was localized at right angles to the axillary border of the scapula, 2 inches below the glenoid cavity, and readily extracted.

In several instances where the foreign body could not be made out by the screen, owing to the flickering of the tube or the glare of diffused sunlight, a diagnosis was nevertheless afforded by a photographic plate, even when the latter was much damaged and imperfect. In this way a bullet was found flattened out like a shilling at the lower end of a leg, and an injured hand was shown to have the metacarpal of the ring-finger fractured.

The supply of focus tubes taken out by the two officers quoted above seems to have been far too small; thus, Beevor took only three, and Battersby only four. When we consider the great risk of damage in transit, to say nothing of perforation during work, to which these delicate tubes were exposed, we would imagine it safer to take, say, several dozen, and to distribute them at various bases of supply. Beside the greater safety ensured by such distribution, it is now pretty well agreed that better results can be obtained by reserving certain tubes for those purposes to which they are best fitted, as, for instance, for penetration or for screen work, instead of attempting to get a number of diverse effects from one or two tubes by varying the spark, current, break, and other conditions.

The experiences of the Röntgen method in the Græco-Turkish War, in the British expeditions to Chitral and the Soudan, as well as in the Spanish-American War, prove conclusively that it may be applied under all conditions likely to be met with in campaigns. Localization seems to be satisfactory, but much remains to be done in the generation of electricity, in the introduction of portable machines of the Wimshurst type, in the improvement of photographic films and sensitized papers, and in the perfecting of screen appliances. In short, the army surgeon, taught by the experiences of the field, must look to mechanical and scientific experts for advances in the direction of portability, simplicity, strength, accuracy, and durability.

Gunshot Wounds in Civil Practice

Apart from military surgery, however, there are numerous gunshot wounds to be met with in civil practice. It is surprising the number of injuries of this kind, accidental and otherwise, that come under treatment in the course of a single year at one of the great general hospitals of the Metropolis. Many practitioners will readily recall the long and fruitless search for the missile that usually took place in their student days. Now all that is changed, and if a bullet be present, it may as a rule be located within a few minutes by the Röntgen ray apparatus which is now attached to every well-appointed hospital.

One great advantage of the new method is the avoidance of the risk of introducing harmful micro-organisms into the wound by means of the probe. In fact, the method may be regarded as an addition of prime importance to aseptic surgery, and it must infallibly lessen the mortality that has been hitherto incident to gunshot injuries. A further gain is that, with a knowledge of exact location, the surgeon can minimize the extent of his operative measures. The latter point is well illustrated in the following case, reported by Dr. E. H. Lee to the Chicago Academy of Medicine:

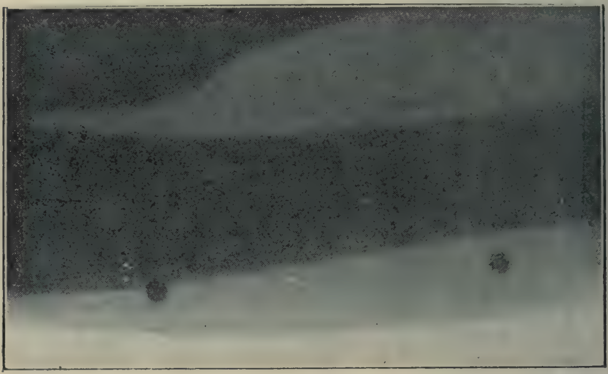

FIG. 32.—SHOT EMBEDDED IN MUSCULAR FOREARM.

'The removal of foreign bodies by means of skiagraphs,' he remarked, 'has opened up a great field of observation in that line. I have in this connection an interesting case, which was that of a policeman who, in pursuing a burglar, shot himself in the heel. The skiagraphs show the bullet embedded in the upper portion of the os calcis. I located the bullet before removing it by Girdner's bullet-probe. By the skiagraph it is seen that the bullet is not located in the joint. This is a point which was of the greatest importance, for the joint was not opened during the operation. It was supposed that we could not remove the bullet without opening the joint, and it could hardly have been avoided had we not had such accurate knowledge of the location.'*

It will be seen, therefore, that the Röntgen methods furnish, as it were, an absolute chart upon which the surgeon may found, not only his diagnosis and plan of operation, but also the hardly less important point of prognosis.

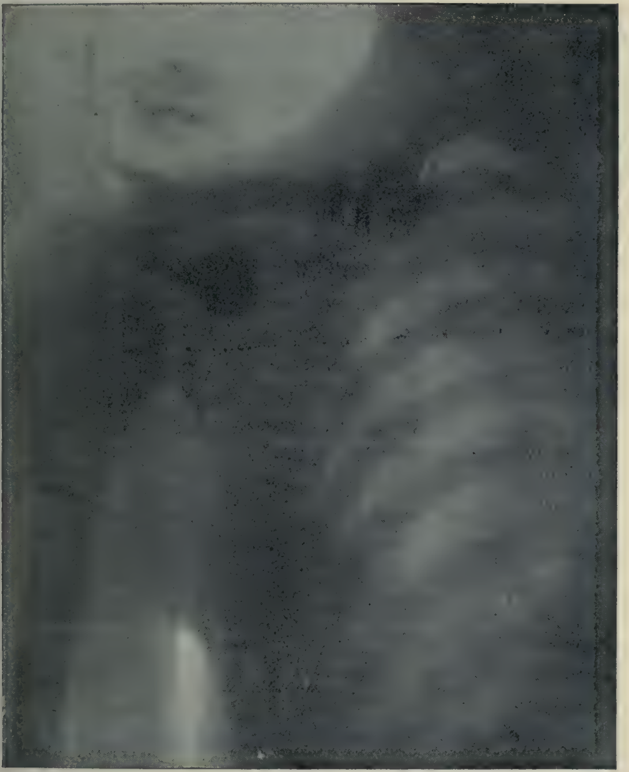

Fig. 33.—Bullet in Shoulder, lying on Scapula. Fired from Front. (Dr. Scott, *American X-Ray Journal*, July, 1899.)

Fig. 32 gives a good idea of the record obtained from small shot. It was taken from the arm of a gentleman who had been accidentally shot twelve months previously. Two pellets lie close to the ulna, a small portion of which is portrayed. They caused no trouble, and as the patient was strong and muscular, their presence could hardly have been detected by any other means. In cases of this kind, where a foreign body has been embedded for a long period of time without giving rise to any inconvenience, it need scarcely be remarked that few surgeons would counsel removal.

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* *The Journal*, Chicago, January 16, 1897, p. 124.

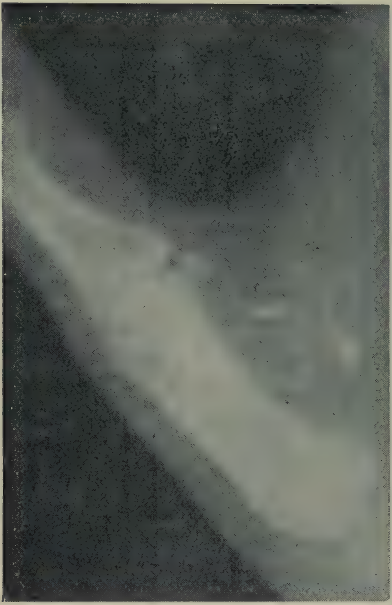

FIG. 34.—THUMB SHOWING LEADEN DÉBRIS AND ABSORPTION OF BONE (DISTAL END OF METACARPAL) AFTER IMPACT OF BULLET. (Mandras.)

The above print is from a photographic film, and reverses the light and shade of an ordinary x-ray, just as happens when the positive print is taken on sensitized paper.

The radiogram of a bullet-wound may help diagnosis in various ways. In the following case, related by Dr. Mandras, of Paris, it threw light upon an injury of the kind long after its infliction :

'M. B—— was struck about fifteen years ago by a bullet from a revolver a little below the distal end of the dorsal surface of the first metacarpal. There was no fracture, but the ball glanced round the bone, and caused an extensive laceration of the tissues at the lower and inner part of the thenar eminence.

'Forty days after the accident the wound was healed, but there was complete loss of power of the thumb. Professor Dubreuil extracted a disc-shaped fragment of a bullet the size of a franc. Soon after a second piece, as large as a lentil, was taken away, followed by a third two and a half months later, but it was a year before the thumb regained its movements.'*

A radiogram of the hand by Messrs. Joubert and Bertin-Sans showed (1) a slight depression upon the metacarpal bone, doubtless due to the destruction of the periosteum by the projectile, and (2) the presence in the ball of the thumb of much metallic débris. By the courtesy of Dr. Mandras, the photograph is reproduced in Fig. 34.

Localization of Foreign Bodies

In order to localize the exact position in the tissues of a foreign body, it is often needful to take a second x-ray observation at right angles to the first. For instance, let us take Fig. 35, which shows a needle to be imbedded in the finger. With so small an object, the surgeon has no clue as to whether it lies back or front of the digit. A cross-photograph, however, will at once settle the point.

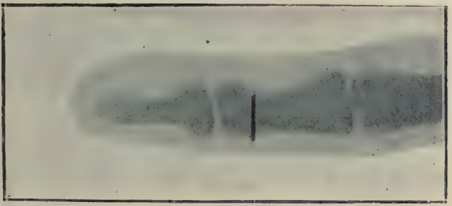

FIG. 35.—NEEDLE IN FINGER, SHOWING EYE.

When the fluorescent screen is used, the surgeon might in some cases be able to localize by means of acupuncture needles. Thus, he might take two views at right angles, and in each pass across the field a needle until it apparently touched the foreign body, or he might first accurately fix the shadow and push an acupuncture needle straight into the tissues in the direction indicated, and then, by a cross-view, ascertain the exact depth to which the needle should be carried. Such a proceeding would obviously be confined in its application to the less vital regions.

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* 'Radiographie en Médecine,' par V. Mandras, M.D., Baillière, Paris, 1896, p. 28.

Other aids to the correct reading of the record of a foreign body are furnished by (*a*) the sharpness of the shadow outline, and (*b*) its size in relation to the original object. These points are both shown in the following experiment of Mr. Greenhill's. A radiogram was taken of a hand with two sections of bullets exactly corresponding in size, placed, the one on the back of the hand, away from the plate, and the other on the palmar side next to the sensitive surface. The difference in the resulting images was striking. That of the lower one was clear, sharp, and almost of the same size as the original section; the other, on the contrary, was darker, larger and more diffuse. This difference in the size of the recorded shadows is explained by the fact that the rays issue from the focus tube in radiating straight lines; the diagram (Fig. 36) will serve to show what is meant. Let F represent a focus tube in action, P the sensitive photographic plate, and A and B two objects of similar shape and size, such as two halfpenny pieces, but A being near the focus tube and B near the plate. It follows, then, as the Röntgen rays radiate in straight lines from F to P, that the shadow *a* will be larger than *b*, inversely to the distance of A and B from the focus tube. In fact, given the distance of tube from plate, and the size of the shadows, the relative position of the intervening objects could be determined by a simple mathematical calculation. Upon this principle, indeed, the chief localizing methods are based.

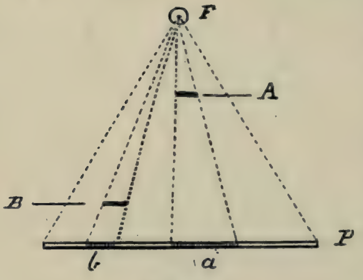

FIG. 36.

It need hardly be pointed out that the ordinary localizing signs and symptoms, such as pain, tenderness, swelling, dyspnœa, and difficulty of breathing or of swallowing, together with the history of the case, will retain their former value to the medical attendant. Such aids to diagnosis, however, are often altogether wanting, and it is then that the surgeon will call in the aid of the Röntgen rays. In short, the philosophical observer will find therein an additional means for conducting exact investigation into regions hitherto inaccessible to either direct or indirect visual inspection.

In practice, the location of an object buried in deep tissues or in the larger cavities of the body often presents peculiar difficulties. Suppose a bullet to be lodged near the surface of the lung, there would be a better chance of finding its exact position than if it were more deeply embedded. In investigating the brain, the photographic field is somewhat obscured, as the rays pass through a large mass of soft material and two surfaces of bone, of varying thickness and density, which under present methods are more or less recorded on the plate.

In the case of a foreign body in the brain, the action of a cross-record may be explained by the following diagram (Fig. 37):

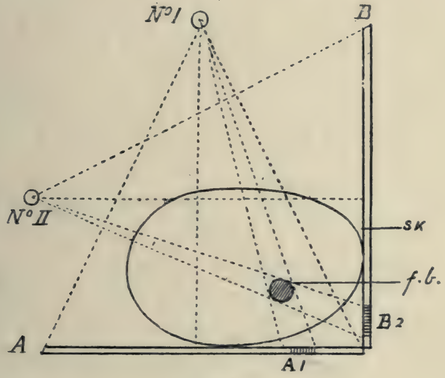

FIG. 37.

Let *sk.* represent the skull; *f. b.* the foreign body; No. I. the lamp, and A the sensitive plate used for the first position; No. II. the lamp, and B the plate for the second position. Then the shadow A1 will fix the plane between No. I. and A in which *f. b.* lies. The exact point of *f. b.* on that plane is determined by the shadow B2 on the second plate B, which fixes the plane of *f. b.* between No. II. and B. In other words, the foreign body lies at the point of intersection of the two planes obtained by the two radiograms taken at right angles the one to the other. In taking the second or cross photograph, the lamp should be placed at exactly the same distance from the plate as in the first exposure. It should also be over an exactly corresponding part of the plate, as, for instance, the centre. In dealing with an oval object like the skull, it will be better to leave the latter in one position and to move the lamp, placing the plate A on the table, and B at right angles. In practice, however, the results are not so easily obtainable as might be inferred from the foregoing explanation. In the above case, for instance, there would be greater difficulty in penetrating the long axis of the skull, and a somewhat longer exposure would be needed for that position.

In one instance, referred to a few pages later, a bullet inside a skull was located by two radiograms : a cross or trans-frontal exposure of eight, and a fronto-occipital of twenty minutes.

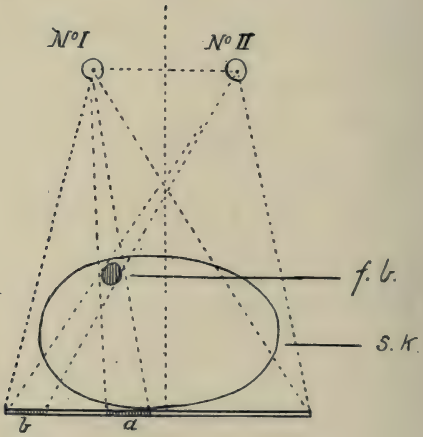

Fig. 38.

Another method, which takes both views in the short axis, is on the principle shown in Fig. 38. Two views are taken by shifting the focus tube, but the body to be penetrated and the sensitive plate remain in exactly the same relative positions. The lamp is put at the same distance from the plate in both views, and also in some known relation to a given point, say the centre or the edge of the plate. By comparing the resulting shadows, a conclusion can be formed as to the intersection of the planes, Ia and IIb. This is the exact principle of the localizing apparatus devised by Mr. Mackenzie Davidson, who places threads on the lines between No. I. and *a*, and No. II. and *b*, and by shifting the focus tube takes two images on one sensitive plate.

Mackenzie Davidson's Localizing Apparatus

The two positions of the anode are secured by sliding the focus tube along a horizontal bar, marked with a millimetre scale, which runs both ways from a central point at zero. Beneath is placed the sensitive plate, or, better, film, protected with black paper in the usual way. On the photographic envelope are laid two wires at right angles to each other, so placed that one of them runs in the same direction as the horizontal bar that carries the tube above, and their point of intersection lies beneath zero on the scale. The cross-wires may conveniently be fastened to a thin board or sheet of vulcanite, and kept in place over the sensitive plate by means of drawing-pins. The wires are painted with aniline ink so as to leave a mark on the body of the patient, and it is convenient further to 'orientate' or identify one of the corners of the plate by some opaque object, as a small coin, with a corresponding sign (in aniline) on the adjacent skin surface. Two equidistant points are marked off by clips at each side of zero on the horizontal slide bar, say at 5, 10, or 15 millimetres, as may be decided by the operator. The focus tube is then drawn up to one side-clip and an exposure made, after which it is pushed over to the opposite clip and a second exposure made of equal duration. The distance from the centre point of the anode to the plate is accurately measured. The operator is then in possession of a number of accurate data from which he may find the exact relation of a foreign body in a patient's tissues to the cross-wires and photographic surface, or, what amounts to the same thing, to the aniline cross mark upon the patient's skin.

In order to work out the problem readily and accurately, Mr. Davidson has devised a 'cross-thread localizer.' The apparatus consists essentially of an adjustable horizontal bar, marked with a millimetre scale starting from a central zero, and notched correspondingly on its upper edge. A plate-glass stage marked with a cross, of which the point of intersection lies exactly beneath zero on the horizontal bar. Beneath the stage is a hinged reflecting mirror.

The developed negative is placed film upwards on the glass stage, and the shadow of the wires made to correspond with the cross mark on the stage. The bar is next raised or lowered so as to bring the zero of the scale to the same distance from the scale as that of the centre of the anode from the sensitive plate when the exposures were made.

Two fine silk threads are next passed over the horizontal scale bar. Each thread has a weight at one end to keep it taut, and is fixed in a notch on the scale corresponding with the distance of the anode from zero during the original exposure. The other end is threaded into a fine needle fixed in a piece of lead. This part of the thread between the notch on the scale and the eye of the needle represents the x-ray, and is movable. With two such threads, then, it will be easy to trace the path of the rays in relation to a body interposed between the focus tube and the sensitive plate as shown in the diagram (Fig. 38).

One threaded needle is placed upon any particular part of one of the photographic shadows of the foreign body, and the other needle upon a corresponding part in the second shadow. The point where the threads cross and touch each other will represent the position of the part of the foreign body chosen for location. A perpendicular is then dropped from the intersection of the threads to the negative below, and a mark made where the perpendicular touches the negative. The distance of the spot thus marked out from the cross-wires is measured by a pair of compasses.

The operator is then in possession of the required measurements. Suppose the distances to be 3 centimetres and 1 centimetre as in the diagram, and the depth from the crossing of the threads to the plate to be 2½ centimetres, then he knows that the foreign body lies at 2½ centimetres from the surface of the patient's skin, at a distance of 3 centimetres and 1 centimetre from the cross-wires, in a quadrant that is easily determined by reference to the distinguishing mark (*e.g.*, coin) placed there when taking the double-exposure photograph.

Mr. Davidson's own words may be quoted: 'The height of the point where the threads cross gives one co-ordinate—that is, the depth of the foreign body below the skin which rested on the photographic plate. The other two measurements give the other two co-ordinates. It will be obvious that these measurements can be noted thus (see Fig. 39).

'As the mark of the wires is left on the patient's skin, all that is required is to measure the two co-ordinates on the skin that give the point below which the foreign body will be found, at the depth given by the third co-ordinate.'*

If the reader have grasped the foregoing description, he will readily perceive that by gauging opposite sides of shadows it will be possible to measure the size of the foreign body. As a matter of fact, such a conclusion can be drawn with quickness and precision. A little practice, however, is necessary, and the

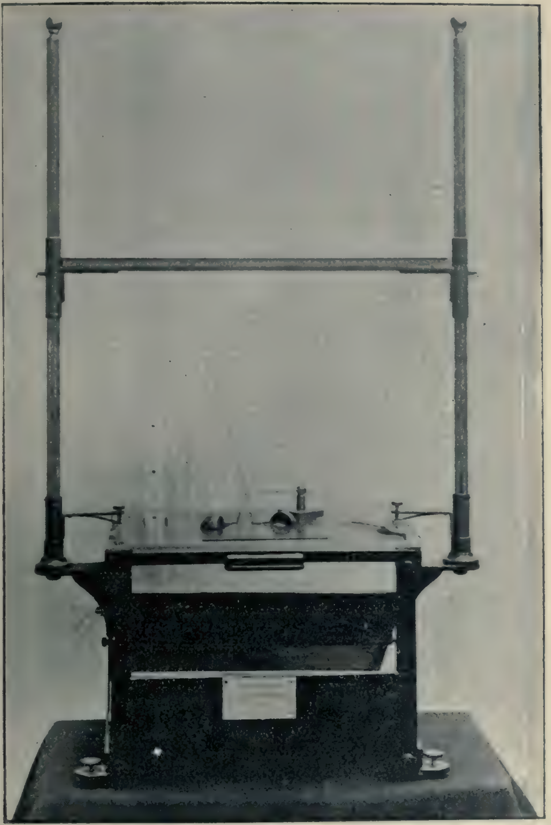

FIG. 39.—MACKENZIE DAVIDSON'S CROSS-THREAD LOCALIZER.†

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* *Archives of the Röntgen Ray*, vol. ii., No. 1, May, 1898, p. 65.

† Made by Messrs. Muirhead and Co., Elmer's End, Kent, and Westminster.

beginner will find it a good plan to localize small objects, such as bullets or shot buried in a turnip or a block of paraffin.*

Dawson Turner and others have published a simple formula for localizing.† Two photographs are taken on one plate by shifting the focus tube. The distances are measured from tube to plate a, between the two positions of the tube b, and between the two shadows on the photograph c. Let x equal distance of the foreign body from the plate. Then $x = \frac{a \times c}{b + c}$. Supposing a to be 33 centimetres, b 10 centimetres, and c 1 centimetre, then

$$x = \frac{33 \times 1}{10 + 1} = 3 \text{ centimetres.}$$

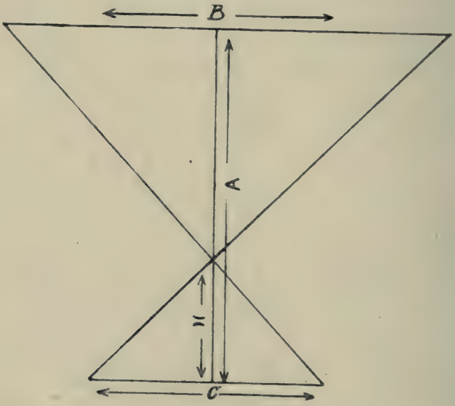

FIG. 40.

Dr. Hedley's combined localizer and vacuum-tube-holder is a modification of Mr. Mackenzie Davidson's apparatus. It serves a double purpose, and is designed with a view to portability and simplicity. It consists of an upright steel bar screwed into a collapsible tripod stand, and carrying a shifting horizontal bar made of wood and graduated, and armed with a travelling clamp that grips the focus tube. A wire cross dipped in an aniline dye is laid on the plate to mark the patient's skin, and the path of the rays is traced by silk threads attached to the scale at points corresponding with the focus tube during the two exposures and carried down to the images on the developed plate, where they

* The apparatus is made by Messrs. Curry and Paxton, of Great Portland Street, London, W. It is kept in two sizes.

† *Scottish Medical and Surgical Journal*, April, 1898.

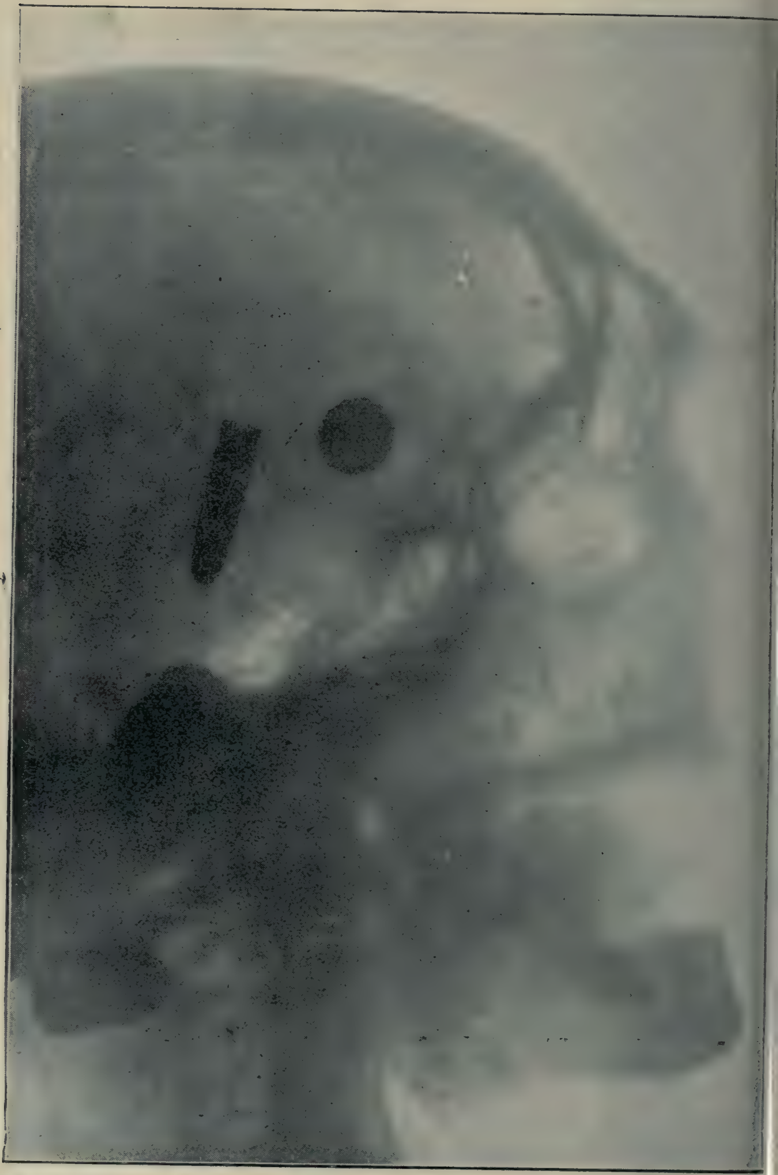

FIG. 41.—THREE BULLETS IN HEAD OF A CADAVER; ONE IN NECK; REDUCE ABOUT ONE-THIRD.

are fixed by small weights. The point of intersection of the threads marks the position of the foreign body.

Mr. Hall-Edwards has a good localizer, in which a chequered grid lies flat over the sensitive plate and beneath the shifting tube. In America the 'Dennis Fluorometer' is in vogue. It consists of an upright grid attached to an operating table, and was used exclusively in the recent Cuban war, where it was found to work rapidly and well, especially in screen-localization.

Foreign Bodies in Brain

By the kindness of Mr. Davidson the writer has been enabled to reproduce the accompanying illustration (Fig. 41), showing bullets artificially introduced into the head and neck of a cadaver. Commencing from above downwards, the round ball at the top was placed in the right frontal lobe of the brain, and the conical bullet next to it also inside the brain, close to the right parietal bone. As the right side of the head was placed next the sensitive plate, both these bullets were brought close to the film, a fact which accounts for their clear definition. For a like reason their shadows in the original photograph correspond nearly in size with those of the foreign bodies. Their sharpness of outline is wanting in the third bullet (from above downwards), which was placed in the centre of the lower portion of the skull cavity, over the basilar process of the sphenoid. The radiographic record of the last missile, moreover, would be larger than the original, owing to its comparative distance from the sensitive plate. Much the same may be said of the remaining bullet, which is deeply embedded in the middle line of the muscles of the back of the neck.

In the absence of definite information as to details, it may be conjectured that the tube, acting strongly from both a photographic and a penetrative point of view, was placed close to the skull, and that the exposure was fairly long. Under those conditions, the side of the skull next the lamp would be reproduced only faintly, if at all, and a reference to the figure will show that it represents mainly one side of the skull, namely, that next to the plate. It will be noticed that the frontal sinus is displayed, the gums are toothless, the tongue well defined, and, lastly, that the excellence of the result is to some extent accounted for by the thin bones, and the fact that the photograph was obtained from a dead subject.

The subject of clearness of definition is admirably handled by Mr. Lewis Wright in his work on the 'Induction Coil.' He states that sharpness can be increased in two ways only: (*a*) by increasing the distance of object and plate from the tube, which, of course, lessens photographic power, but is useful in some cases; and (*b*) by reducing the radiant* almost to a point. The following passage is so clear and practical that the intending operator will do well to study it carefully: 'As Dr. Macintyre has pointed out, the problem confronts us, when we deal with subjects of great depth, in a more complicated way. Suppose we want a radiograph through the entire human body, or through the entire cranium. We have now to consider *what* we want. If we remove the focus tube to a distance proportionate for the much greater thickness, to 9 or 10 inches for the thickness of the hand, our shadow of all the structures would be of approximately equal sharpness. But in the first place, such a distance will afford far too feeble radiation; and in the second place, even supposing that we could thus get shadows of all the structures superimposed, these would only confuse each other. What we want is some definite portion, the less confused by images of the rest, the better. These objects are best attained by placing the focus tube as close as possible to the structures we do not want. If we seek for a suspected injury or disease of the bone on one side of the cranium, therefore, we bring the tube close to the other side, and the photographic plate close to the side we wish to photograph. Then the shadows of the side next the tube are so diffused and dispersed and enlarged that they practically disappear; while the details are sharp of the side in contact with the plate.'

An admirable instance of ingenious intracranial localization has been kindly furnished to the present writer by Professor Waymouth Reid, of Dundee. Owing to the shedding of hair that followed the first exposure to the Röntgen rays, he found it impossible to procure a cross-photograph. Although the plan he adopted does not stand comparison with more recent methods, it nevertheless has a distinct historical value; and the case presents features of great clinical interest, so that a short account may be here inserted:

The patient, a young gentleman, from whom the radiogram

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* 'The Induction Coil.' Lewis Wright, p. 150. Macmillan and Co., 1897.

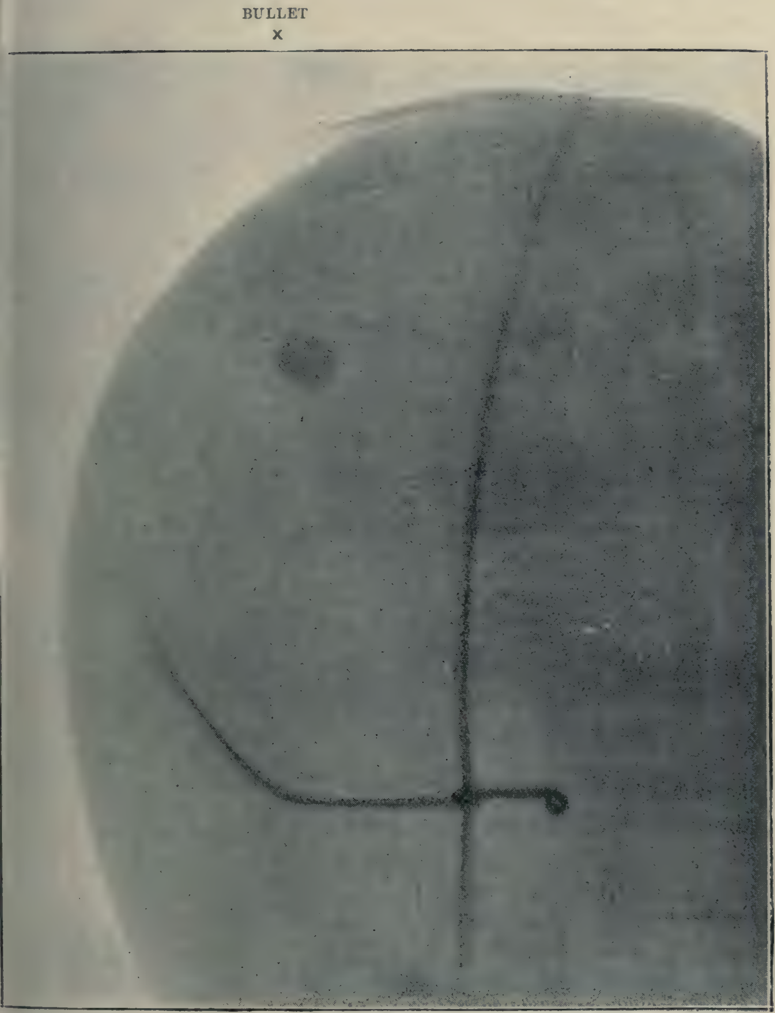

Fig. 42.—Bullet in Brain (or within Skull) of Living Subject. Lead Wire Cage used for localizing.

Professor Waymouth Reid's case.

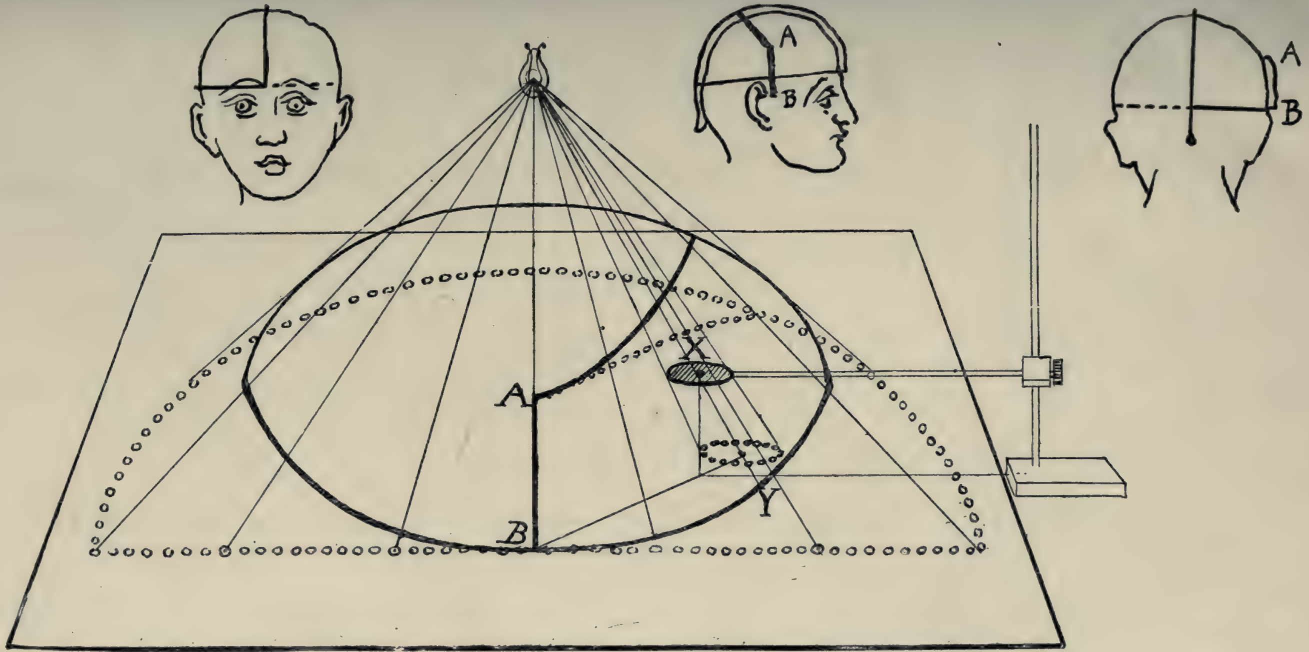

Fig. 43.—Diagram explaining Dr. Reid's Case (see preceding figure).

was taken, accidentally shot himself by a bullet from a revolver on May 21, 1891. He came under the care of Dr. Blaikie Smith, of Aberdeen, who published an interesting account of his case.* When found after the accident, blood and brain matter were oozing from a wound in his forehead, a little above and to the outer side of the right supra-orbital foramen. A director passed into the aperture of the frontal bone, and through the substance of the brain, reached somewhere near the upper extremity of the fissure of Rolando. With regard to the track of the bullet, Dr. Blaikie Smith remarked : 'It seems clear, from the position of the opening in the skull, that the missile penetrated the brain about the lower part of the first frontal convolution. Continuing its course obliquely upwards through the convolution, it apparently next entered the motor area of the brain, producing, as direct results, paralysis of the arm and leg on the opposite side.'

Strange to say, the patient recovered entirely from this serious wound. Five years after the accident, at his own request, a Röntgen ray photograph, reproduced in Fig. 42, was taken by Dr. Reid, to whom the writer is indebted both for the illustrations and for the notes of his method of localization.

An external landmark was secured by means of a head-cage of leaden wire fitted to the right side of the head, which was placed upon the sensitive plate. The cage was constructed and fitted in accordance with the measurements given by Poirier ('Traité d'Anatomie Humaine,' 1895, t. iii., p. 431).

A tracing of the Röntgen photograph was fixed to a flat surface, and over it was nailed that portion of the wire cage rising vertically from the Sylvian line, so as exactly to cover its own shadow mark (A, B in the sketch, Fig. 43). A small surgical incandescent lamp was then suspended at the height of the anode of the focus tube, as measured in the first place when taking the photograph. The lamp was then moved laterally until the shadows of the cage were cast upon the tracing of the original negative. By that means the incandescent lamp was placed in a position corresponding precisely with that of the anode in the first exposure. Paper discs of varying size were next interposed beneath the rays at X, until their shadows fitted those on the tracing Y. Measurements were then taken upon the curved wires of the lead cage, just as they would be upon a patient's head before operating.

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* *British Medical Journal* for September 17, 1892.

Clearly, the depth of the bullet might be calculated very differently by this method, according to the size of the interposed disc. Accordingly, a bullet of the same size as that with which the patient shot himself was obtained, and three discs were cut—(1) of same diameter, (2) half as large again, (3) double the size.

No. 1 indicated a location on the *left* side of the brain. The shadow on the original radiogram, however, was too sharp for such a position. Moreover, the bullet must necessarily have been more or less flattened by frontal impact. Lastly, the clinical symptoms pointed to a right-sided injury.

No. 2 showed bullet on the right side $1\frac{7}{8}$ inches up from the Sylvian line, $2\frac{3}{4}$ inches back from the vertical rising to Rolandic line (A, B), at a depth from surface of 2 inches.

No. 3 fixed the foreign body on the right side close to the surface, $1\frac{1}{2}$ inches above the Sylvian line, and $3\frac{3}{4}$ inches back from the vertical rising to the Rolandic line.

This last inference is probably the correct one. Dr. Reid concludes that the bullet, after it had traversed the brain, came to a dead stop, flattened against the inner surface of the skull.

It is interesting to note that this highly ingenious—indeed, brilliant—x-ray diagnosis nearly confirmed that arrived at in the first place by Dr. Blaikie Smith. In his published account of the case, that gentleman wrote: 'In all probability, the bullet has become arrested either in the leg centre or in its immediate vicinity. The exact situation is open to doubt; *possibly the future may determine its position with greater accuracy than can be done at present.*' In the light of recent events, the remarkable passage printed in italics reads like an inspired prophecy. Dr. Smith, however, has explained to the writer that what he had in mind was the possible future development of localizing signs. He has added that when he last saw the patient the left knee jerk was still exaggerated, and the left hand apt to become cold from slight causes, the latter result being perhaps due to trophic disturbances.

A somewhat similar case has been published by Dr. Fattic in an American journal.* A boy of nine was shot in the forehead—

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* *New York Medical News*, August 28, 1897.

½ inch over the superciliary ridge, and 1 inch to the right of the median line—with a revolver bullet of small bore (32 calibre). The wound passed upwards, backwards, and slightly outward, but the missile could not be felt by a sterile probe passed in for a distance of 3½ inches. Antiseptic irrigation and dressings were applied, and shock overcome by free stimulation. The lad had complete paralysis of the left arm for a week, after which time he got gradually well. Seventeen months after the accident the bullet was located close to the frontal bone by two exposures—a trans-frontal one of eight minutes, and a fronto-occipital of twenty minutes. Dr. Fattic's explanation of the position of the foreign body may be gathered from the following note: 'From the history of the case it is evident that the motor area of the right side of the brain, controlling movements in the left arm, was injured, and the relief from the paralysis and the present location of the bullet, as shown by the radiograms, warranted the belief that the missile must have retraced its passage along the brain wound, assisted by the force of gravity.'

Messrs. Rémy and Contremoulin have devised an ingenious method of localization, which was laid before the Paris Academy of Medicine on March 20, 1897. Having taken two radiograms by a Crookes' tube in different positions, they were enabled by means of a geometrical figure to determine the exact position of a foreign body. Then, by a special apparatus, somewhat like the compass used by sculptors, they were able to fix with mathematical accuracy the depth of the object from the surface.

An interesting case, recorded by Max Scheir, was that of a man of twenty-seven, who had received a gunshot wound above the right superciliary ridge. From the symptoms it was imagined that the bullet had lodged in the orbit, which was explored, but without success. Five years later the rays revealed a foreign body somewhere near the Gasserian ganglion. A radiogram taken at the time would have prevented the useless exploration of the orbit. Moreover, had the bullet been removed by operation, the patient might have been spared the ensuing paralysis of the fifth (except its motor branch) and of the olfactory and optic nerves.

Many other bullets have been detected in the brain by the Röntgen rays.* Thus, Eulenberg described two such cases. In the first the foreign body was found in the right middle fossa of the skull, a little to one side of the median line; in the second it was shown close behind the orbital fissure. In detecting a bullet in this position, it is of practical importance to note that it may sometimes be readily seen by means of the fluoroscope where a long exposure (an hour) has failed to obtain a photographic record, as in a case described by Dr. Bruce.* In such an event it would be possible to locate with the tube in two positions (A, B) by bringing an opaque object into line with the foreign body, and then marking the entry and exit of that line on the skull. The point of intersection would be the site of the bullet. A special instrument for marking is the 'punktograph.'

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* *Deutsch. Med. Wochenschrift,* August 17, 1896.

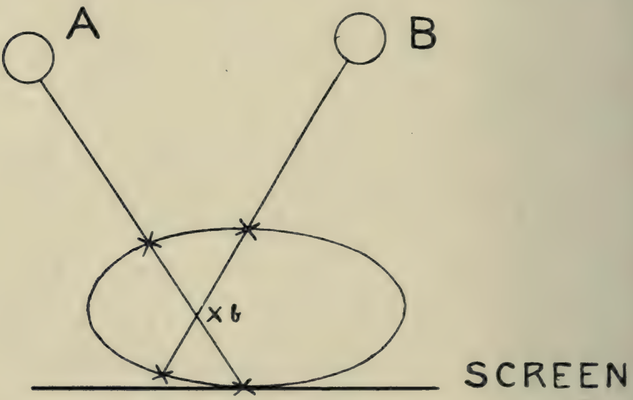

Fig. 44.

Foreign Body lodged in Spine

Dr. Phelps, of New York, has reported a case where a revolver bullet struck the thyroid cartilage, and, after passing through the neck, lodged in an unknown part. A radiogram showed a dark spot in the fourth cervical vertebra, and with the knowledge thus gained the surgeon was enabled to operate successfully. The ball had struck the hard lamina of the vertebra and flattened out, after which it had barely penetrated the canal. Recovery was uneventful.

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* *Medical Record*, April 17, 1897.

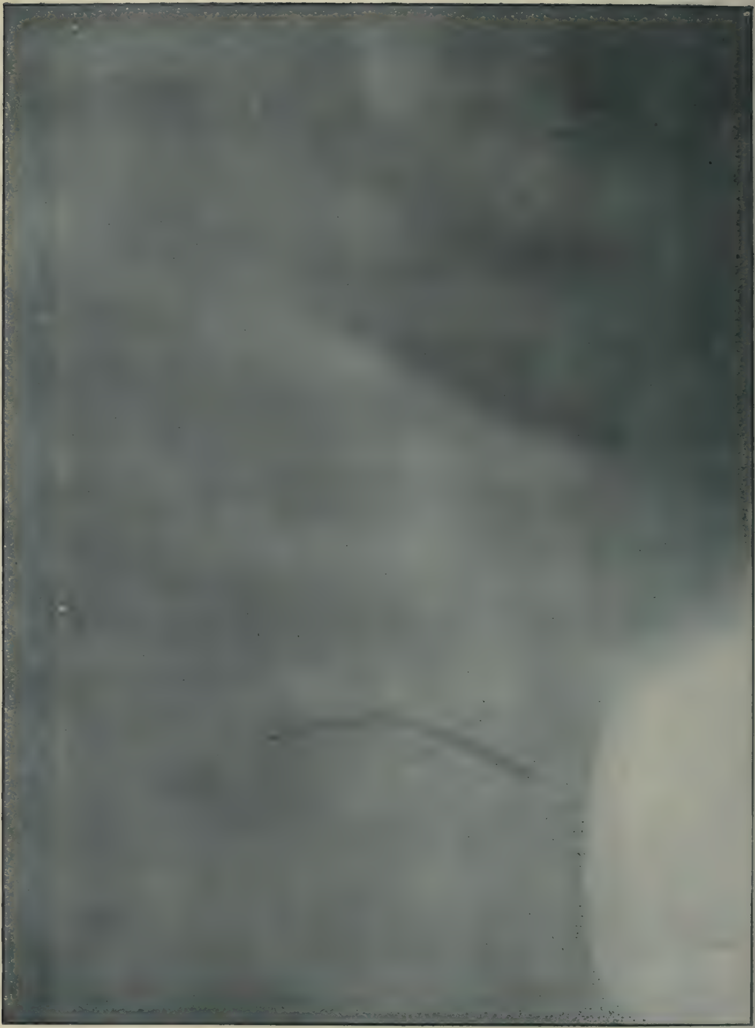

Plate I.—Pin in Larynx.
D. J. Mackintosh, M.B. [*To face p.* 103.

Foreign Bodies in Neck and Thorax

Such objects as coins and buttons have been detected in the larynx, bronchi, lungs, mediastina, and pleura by means of the Röntgen rays. In most of these sites, however, it is likely that the clinical signs and symptoms will afford an equally ready means of diagnosis.

Dr. Walker Downie, of Glasgow, found a pin which had slipped into the larynx from the mouth. The foreign body could not be seen by the laryngoscope, but the patient, a boy, complained of 'a pinching pain at the back of the throat, and some pain in swallowing.' The pin was discovered by the rays, and easily extracted by external operation.* Dr. Downie has kindly allowed the accompanying reproduction (page 103) of his original photograph. It was taken with an exposure of eight minutes to an Apps coil having a 10-inch spark.

The plate shows parts of upper and lower jaws, with some of the molar teeth and their fangs. To the left are several of the cervical vertebræ, and in front, under cover of the lower jaw, is the hyoid bone, below which a light perpendicular band indicates the position of the larynx and trachea, structures which are particularly translucent. Crossing this light area, at the level of the lower border of the body of the fourth vertebra, is the pin with the head anteriorly, corresponding to the outline of the thyroid cartilage, and with its point embedded in the cartilaginous disc between the fourth and fifth cervical vertebræ. The pin appears at least $\frac{1}{4}$ inch longer than the antero-posterior diameter of the larynx, and it is bent near the middle, with the convexity directed upwards.

In an antero-posterior radiogram the pin was localized by means of two pieces of silver wire fastened with sticking-plaster, the one in the middle line, and the other at right angles in a carefully-noted position. In the picture the two wires were shown fixed to the skin, and $\frac{11}{16}$ inch above the horizontal one was the image of the foreshortened pin, with the head close to the middle line, from which point the body of the pin was directed upwards and backwards. It is interesting to note that there was no indication of the vertebræ, through which the rays must have passed to give the image of the pin shown in the photograph. That result is doubtless due to the high penetrative action of the focus tube, as well as to its nearness to the spine.

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* *Edinburgh Medical Journal*, January, 1897.

The principle of localizing by means of wires is capable of extensive application. Soft lead wire is suitable, and may in many cases be twisted round a limb. If fastened on with plaster, it should be remembered that most forms of that material are opaque to the rays, owing to the contained lead.

Dr. Downie has reported another case in which a pin was localized outside the larynx in a line behind the right thyroid cartilage, and removed by forceps.*

The beginner will do well to study all the figures attentively. In this way he will train his eye to the recognition of various objects, and will also prepare himself for the more difficult task of reading the fluorescent screen. Unfortunately, there is a loss of detail in almost any kind of reproduction for book illustration. This is especially the case when the original radiogram is reduced on the block.

An indiarubber drainage-tube, when lost in the pleura, may now and then be located by the rays. However, as a rule it will yield no readable record, falling as it does within the uncertain region of faint soft tissue shadows.

There is doubtless a great field of future usefulness for the Röntgen processes in lung surgery. That fact is well illustrated in a case published by Dr. White, of Pennsylvania.† 'I have now under treatment,' he writes, 'a young lad who accidentally shot himself with a 22-calibre parlour rifle. The ball entered the wall of the right chest on the mid-axillary line in the sixth interspace. The muzzle of the rifle was pointing upward. The patient complained bitterly of pain under the upper border of the right scapula. The history of the case and all the clinical phenomena would have led to exploration in that region, but the radiograph shows the bullet in the lower lobe of the lung, on a level with the tenth rib, and near the middle line of the body. The picture also shows in a convincing manner a pulmonary area (corresponding to the lower lobe) of increased opacity, and evidently the seat of blood-effusion and inflammation. The patient has all the clinical symptoms of a traumatic pneumonia.

'There can be little doubt that the difficult decision between

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* *British Medical Journal*, October 22, 1898, p. 1243.

† *The American Journal of Medical Science*, January, 1898, p. 4.

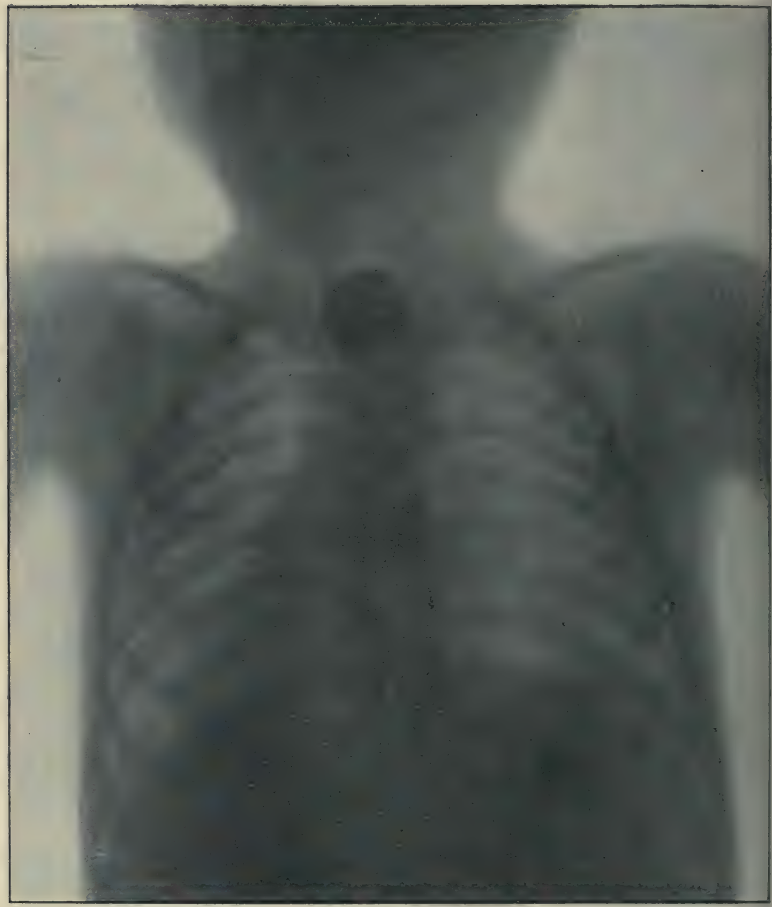

Plate II.—Coin in Gullet.

[*To face p.* 105.

operative interference and expectancy in penetrating gunshot wounds of the thorax without wound of exit will be greatly facilitated in the future by the accurate localization of the bullet.'

In the œsophagus it is fairly easy to locate false teeth and other objects opaque to the rays. Thus, a London medical journal* commented on a case where the results of such an attempt, although negative, were nevertheless of an instructive nature. The facts were briefly as follows: A young lady swallowed by accident a set of false teeth. She called in a medical man, who, failing to remove the impacted plate from the gullet, pushed it, or thought he pushed it, down into the stomach. Some time later she went to a hospital, complaining of pain in the abdomen, and that region was radiographed, but without result. Shortly afterwards she brought up a quantity of blood, and was taken to another hospital, where she died while an attempt was being made to radiograph the abdomen, to which part pain was referred to the last.

Post-mortem it was found that the plate had lodged in the œsophagus below the bifurcation of the trachea, whence it had ulcerated into the aorta. This case suggests the advisability of examining the thorax at once by means of the rays whenever a person has been unfortunate enough to swallow a dental plate.

Dr. Barry Blacker has reported the following case: 'A. B——, æt. 48, male. Swallowed set of false teeth consisting of plate and eight teeth, seen in lateral view between the levels of the cricoid and thyroid cartilages, immediately in front of the bodies of the vertebræ, and in the antero-posterior view from behind as a semicircular object, with the convexity to the right side of the vertebræ, about 2 inches in length."†

If a foreign body be found impacted in the upper part of the gullet, the surgeon may decide forthwith to perform an œsophagotomy. Indeed, it is chiefly on account of the difficulty of localizing such objects that this operation has been hitherto of rare occurrence. As in the foregoing instance, where a foreign body is impacted in the gullet, the occurrence of gastric pain is apt to be misleading. Dr. Macintyre has described a case where a boy swallowed a halfpenny some six months previously. The fluorescent screen showed the coin to be lodged opposite the third dorsal vertebra. In that instance the pain was constantly referred to the stomach. Indeed, where pain in that region cannot be explained by some obvious cause, the surgeon will do well to make the x-ray examination of the chest a routine practice.

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* *Medical Press and Circular*, January 13, 1897.

† St. Thomas's Hospital Reports, 1897.

An excellent example of a coin impacted in the œsophagus was brought forward at the Clinical Society of London on June 22, 1897, by Mr. Bowlby. The patient, a boy three and a half years of age, was under the care of Mr. Howard Marsh. He had been under observation for five weeks, during which time he showed no symptoms beyond occasional sickness. A radiogram taken by Messrs. Allen and Hanbury (page 104) at once revealed the presence of the coin, a halfpenny piece, lodged in the gullet at the level of the second dorsal vertebra. Removal was ultimately effected by means of a catch carried within a gum elastic catheter.

Dr. Mayo, of Rochester, U.S.A.,* has reported a case where an open buckle was shown by the radiograph to be impacted in the gullet of an infant. The buckle lay behind the upper part of the sternum, with its teeth projecting upwards and to the right. A left œsophagotomy enabled the surgeon to remove the foreign body by means of a bent probe. The chief point of interest was that the position of the teeth would have effectually prevented the pulling upwards of the buckle. The danger of attempted extraction by curved forceps would obviously have been great.

Professor White, of Pennsylvania, had a child, two years and five months old, brought to him with an obscure history of dysphagia and vomiting. The Röntgen rays showed a cruciform toy known as a 'jackstone,' impacted in the œsophagus on a level with the space between the second and third dorsal spines, a little above the bifurcation of the trachea. The object was in the shape of a Maltese cross, with an additional bar at right angles through its centre. As it could not be extracted by the mouth, gastrotomy was performed, and the 'jackstone' drawn down into the stomach and removed.

Mr. George Heaton, of Birmingham, has recorded† two interesting cases of coins that had been impacted in the gullet for a considerable time, but gave little evidence of their presence. In one case the foreign body had been swallowed three months, and in the other forty days previous to detection by the rays. One patient took solids and fluids freely, the other fluids only.

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* *North-Western Lancet*, March, 1897.

† *British Medical Journal*, June 4, 1898, p. 1449.

Among numerous other instances, the following may be selected. Dr. Bliss* found an iron staple an inch long, with two sharp points, so fixed in the gullet that the use of a probang would have still further impacted the foreign body. Removal could not be effected by curved forceps until the exact position of the staple and the direction of its points had been localized by means of the Röntgen rays.

In this class of cases the importance of the Röntgen rays can hardly be overestimated. As every surgeon knows, the difficulty of locating is often extreme. Undetected foreign bodies in the gullet have been treated for pulmonary phthisis, croup, catarrh, asthma, and so on. Wallace of Edinburgh has recorded a case where a plate bearing six artificial teeth could be located only after repeated negative attempts with the œsophageal olivary bougie and 'coin-catcher.' A low œsophagotomy proved a failure, and gastrotomy was finally required.

White has suggested the combined use of instruments, as the curved forceps, with the fluorescent screen. A similar suggestion has been made by Mr. T. L. Gillanders, M.B.† After failure to find a bullet in a hand, where it had been shown by the rays, he removed it by observing its relative position to the bullet forceps upon the fluorescent screen. The first negative result was due to the fact that the bullet had become flattened against the bone, and was bound down tightly by the powerful flexor tendon. Mr. C. G. Burton, of the North Eastern Hospital for Children, London, has recorded another interesting case of a coin thus removed (*British Medical Journal*, April 1, 1899).

Foreign Bodies in Abdomen

So far as the abdomen is concerned, coins and other foreign bodies have been located in the case of children. The importance of exact information of this kind will be at once recognised by those who are familiar with the needs of abdominal surgery. The results of ray work, when applied to the abdomen in adults, have for the most part been either uncertain or negative. However, a good definition of intestines and other abdominal organs can be procured in the case of small lower animals, and also of children. In the face of such facts it may be confidently anticipated that before very long it will be possible to obtain satisfactory ray pictures of the abdominal viscera in the adult human subject. From time to time different experimenters have succeeded in obtaining an obscure record of intestines. The present writer has such a result in the shape of a photograph taken in the summer of 1897, which shows a faint, but discernible, tracing of colon, of loops of small intestine, and of the sigmoid flexure of the rectum. The patient from whom the radiograph was taken had signs of chronic intestinal obstruction. On the chance of localizing the lesion, he was given bismuth in 10-grain doses thrice daily for over a week before the abdomen was examined by the rays.

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* *International Medical Magazine*, March, 1897.

† *British Medical Journal*, May 14, 1898, p. 1252.

The advantages of localization of foreign bodies in the intestines of adults need hardly be pointed out. Numerous possibilities will readily occur to the mind of the medical reader, such as the detection of a forceps or other instrument inadvertently sewn up in the abdominal cavity. The passage of a Murphy's button through the bowel has been repeatedly demonstrated. The knowledge of the progress of a foreign body through the intestinal canal not only guides the surgeon in his prognosis, but must also afford great relief to the anxiety of the patient and his friends.

Foreign bodies can be detected in the pelvis, either in the rectum or the bladder. Calculi in this and in other parts of the abdominal cavity will be discussed in another part of the book (see p. 117).

Foreign bodies can be readily detected in the stomachs of children. The same thing has also been now and then accomplished with adults. Thus, Dr. Scott of Kansas[1] has published the following interesting case, accompanied with a Röntgen photograph:

'Radiograph of abdomen of ostrich-man, Mr. G. W. Whallen, taken by Dr. E. Von Quast. The dark mass on the left side of the picture contained 116 different pieces of metal and a handful of glass. Patient operated upon, June 8, 1897, at German Hospital. Occupation, showman; 26 years old. Median gastrotomy. The following foreign bodies removed: 3 ounces glass, two pocket-knives (one a Varlow 4½ inches long, the other a four-blade), five knife-blades, one barb-wire staple, three screws, one horseshoe nail, sixteen tacks, forty-one wire nails, forty-one twelve-penny nails. On account of the weight of the above articles the stomach was lower down than normal. The outline of the articles does not show, as they were all rolled up in a round mass. Patient emaciated from want of food, as he could not eat anything for about a week before operation. Foreign bodies had been in stomach for two or three weeks. After operation the stomach was closed by interrupted and Lembert sutures. Death in forty-eight hours from enteritis and exhaustion. There had

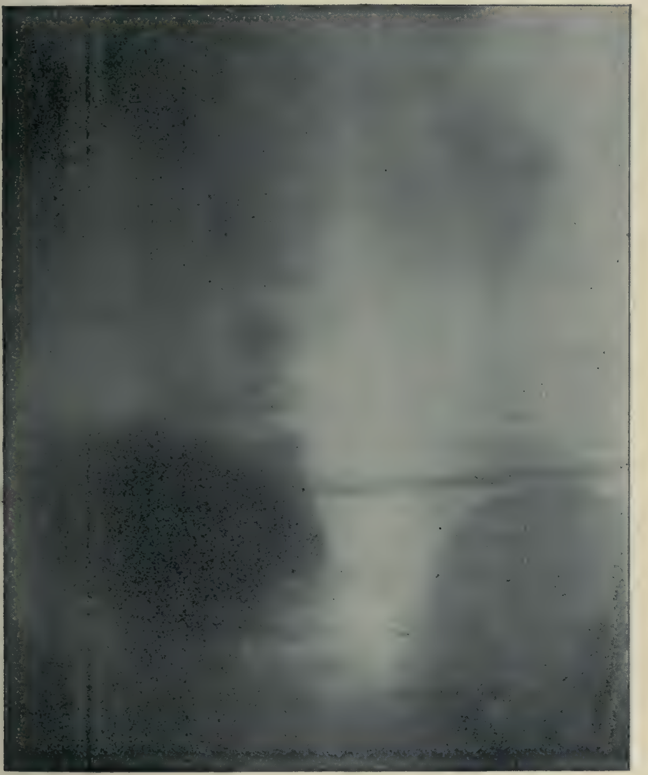

Fig. 45.—Stomach of "Ostrich Man" distended with a mass of Metallic Articles and Glass, which caused his death (*American X-ray Journal*, July, 1898).

been hæmorrhage from the bowels. The post-mortem showed absolute union of wound in stomach; no leakage; wound healed in part.'*

In the same article Dr. Scott shows the radiogram of a swallowed watch in the lower end of the œsophagus of the ostrich-man. Immediately after the photograph was taken the patient removed the watch by means of the attached chain. Both watch and chain stand out in dark shadow upon the less dense record of the heart and spine. In the lower part of the course the chain bends slightly towards the left, thus following the direction of the œsophagus. The subject of this experiment was in the habit of swallowing wadded cartridges, tacks, money,

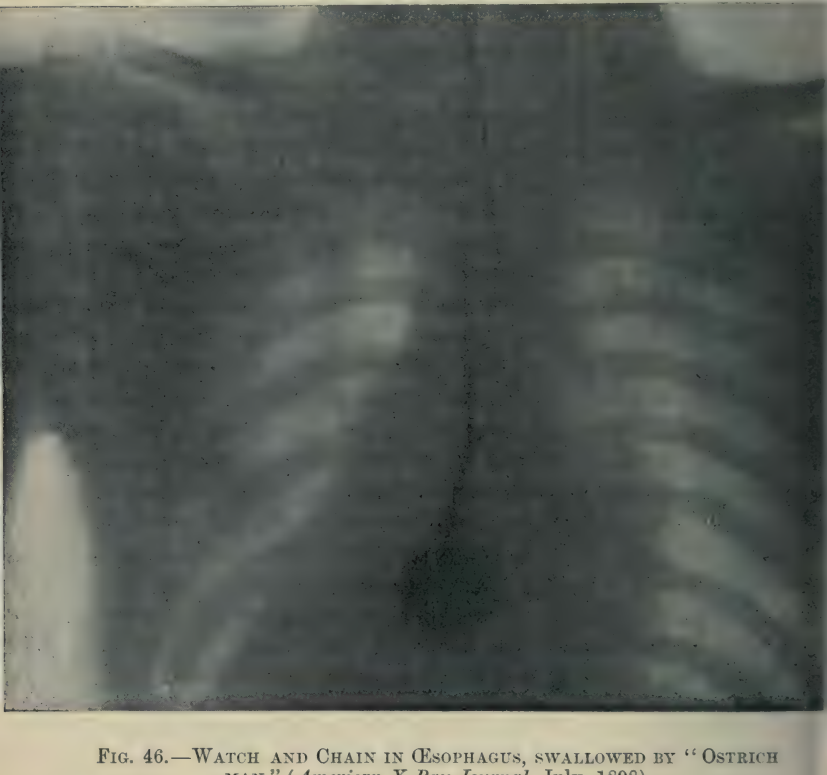

FIG. 46.—WATCH AND CHAIN IN ŒSOPHAGUS, SWALLOWED BY "OSTRICH MAN" (*American X-Ray Journal*, July, 1898).

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* *American X-Ray Journal*, July, 1898.

screws, and other solid articles, at public performances. He stated that as a rule he passed metallic bodies in twenty-four hours. A failure in the latter respect appears to have led to an accumulation and fatal result.

Dr. White has suggested* that in suitable cases the presence of a foreign body in the stomach could be demonstrated by moderately distending that organ with a harmless opaque fluid, like lime-water, and observing whether or not the body disappeared from view.

Linderman suggests the outlining of a dilated stomach by means of a soft stomach-tube armed with a flexible metal style. A relative landmark on the abdomen is obtained by fixing a small coin to the umbilicus.

Foreign Bodies in the Eye

The Röntgen ray exploration of the eyeball, buried, so to speak, in a dense bony socket, was in the early days of Röntgen work attended with insurmountable difficulty. Now, however, it may be readily performed by the use of a tube of good penetration and definition, and in some cases yields results of great value.

So early in the history of the method as March, 1896, Professor Van Duyse communicated some interesting experiments to the Medical Society of Gand. He introduced a shot into the eye of a rabbit, and pushed it up behind the iris towards the centre of the lens. He then, with the aid of a local anæsthetic, produced an exophthalmos, and slipped under the protruding eyeball a small sensitive plate. The result, an extremely sharp shadow, is shown in Fig. 47.

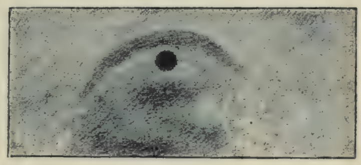

FIG. 47.—SHOT IN EYEBALL OF RABBIT.

An important point is that the foreign body could not be detected by the ophthalmoscope.

This second picture (Fig. 48) shows a pellet and a fragment of lead introduced into the equator of a human eye after removal from the body. His main conclusion was as follows: 'To obtain a shadow of metallic bodies lying in the anterior chamber, it will suffice to place, in the inner angle of the lids, a small sensitive plate or film of which one of the corners has been rounded, and to turn on the x-rays from the temporal side.'

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* *Deut. Med. Woch.*, April, 1897.

For the use of both the above illustrations the writer is indebted to the courtesy of Dr. Van Duyse.

Many cases have been reported of the detection by the rays of foreign bodies in the living human eye.

Dr. Leukowitsch,* one of the early workers in this direction, obtained good results in sheep's eyes with two tubes, but found it better to use one tube and take two views.

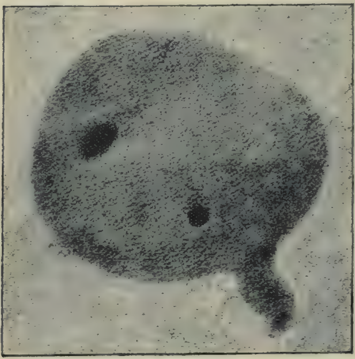

FIG. 48.—PELLET AND FRAGMENT OF LEAD IN HUMAN EYE.
Van Duyse.

For the living human eye he used small semicircular sensitized plates, as that shape allowed the largest possible area to be inserted at the inner angle of the eye opposite the lachrymal bone. By rolling the eye inwards or outwards, a large part of the globe could be brought within range of the rays. Rotation, however, rendered a fixing-point necessary. This he obtained by a glass indicator, bent twice at right angles, with a short straight terminal placed so as to point exactly to the antero-posterior axis of the centre of the cornea. In this way he obtained localizing radiograms of a foreign body (a sequin) placed on the conjunctiva of his own eyeball.

In February, 1897, two cases of steel fragments in the vitreous humour were brought before the Ophthalmological Section of the College of Physicians, Philadelphia, by Drs. Oram Ring and Hansell. The latter gentleman mentioned another instance communicated to him verbally by Dr. de Schweinitz, who found a foreign body by the rays, and afterwards extracted it by the Hirschberg magnet. Dr. Hansell, in a communication to *The Journal*, Philadelphia, observed : 'Thus it will be seen that the bony walls of the orbit and the coats of the eye are permeable to the rays. By comparison of the shadow of the metal with that of the margin of the malar process of the superior maxillary bone, and the knowledge of the relation of the Crookes' tube to the sensitive plate, the location of the foreign body can be closely estimated.'

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* *Lancet*, August 15, 1896.

Dr. Stern, of the Philadelphia Polyclinic, however, claims by an original method to have succeeded six times in demonstrating, by both fluoroscope and radiogram, foreign bodies in the eye, undiscoverable by other means. In each instance he reported subsequent removal by ophthalmologists. Before he detected the fragment in the case of Dr. de Schweinitz's patient, the eye had actually been cut down upon once, and the magnet applied three times with negative results.

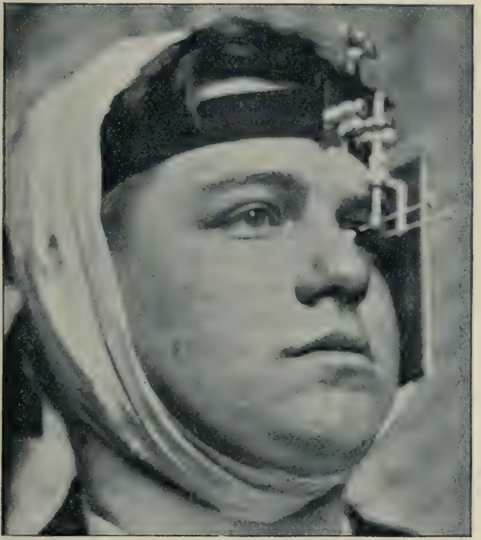

FIG. 49.—SWEET'S LOCALIZING APPARATUS.
From *The Practitioner.*

Good records of small shot and fragments of wire introduced into orbits were obtained by Dahlefeld and Pohrt.* Their plan was to place the sensitive plate against the temple of the affected side, and to place the focus tube at a distance of 10 to 15 millimetres distant from the opposite temple. Then came the stage of exact localization, which in certain cases has rendered the x-rays invaluable to the ophthalmic surgeon. In America, Dr. Sweet* and Dr. Kibbe† appear to have led the way; and Dr. Sweet took Röntgen photographs in one or more of Dr. Hansell's cases where extraction followed. Dr. Leonard's method was published in April, 1898,‡ two months later than that of Mr. Davidson in England.§

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* *Deut. Med. Woch.*, No. 18, 1897.

An excellent account by Mr. Treacher Collins, of the Röntgen rays in relation to ophthalmology, was published in the *Practitioner* for August, 1898. He describes Dr. Sweet's method thus:

'Dr. Sweet fixes to the patient's head an "indicating apparatus," carrying two steel rods each, with a rounded ball at the end. These balls are placed at a known distance from the eyeball, one pointing to the centre of the cornea, the other to the external canthus, both parallel to the visual line and perpendicular to the plate.

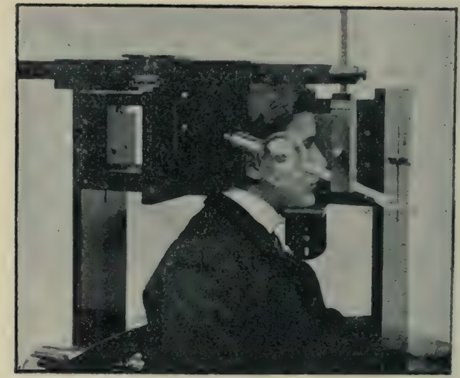

FIG. 50.—DAVIDSON'S EYE APPARATUS.

'From the relation of the images of these balls of the indicator to that of the foreign body in the skiagraph he is able to work out, on a horizontal and vertical diagrammatic section of the eyeball, the approximate position of the foreign body.

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* *Trans. Amer. Ophth. Soc.*, vol. viii., p. 88, 1897.
† *Archiv. of Ophth.*, vol. xxvi., p. 517, 1897.
‡ *Philadelphia Medical Journal*, February 5, 1898.
§ *British Medical Journal*, April 28, 1898.

'In a patient of Dr. W. Thomson, of Philadelphia, who had received an injury to the eye eight months previously, Dr. Sweet predicted that the piece of steel would be found below the horizontal line of the eyeball, to the temporal side of the vertical one, and 20 millimetres from the cornea. The foreign body was subsequently removed by operation from the position indicated.'

Mr. Davidson applies the photographic plate, fixed in an angular rest, to the temple on the affected side of the patient, who sits upright. A loop of lead wire is fixed by sticking-plaster to the edge of the lower lid, opposite a known point of the eye; the point of this wire, projecting upwards, forms the landmark from which the position of the foreign body is calculated. The patient is directed to gaze steadily at a distant object in an axis parallel with the plate—that is, straight in front—and two exposures are made on the same plate with the tube in different positions on the sliding bar. Localization is made from the resulting photographic records in the manner already described, and has now been successfully applied by many ophthalmic surgeons.

Mr. T. Collins, at a meeting of the Ophthalmological Society on January 27, 1898, described a series of cases in which the above method had been used. In none of them could the presence of a foreign body have been determined from the clinical appearances. In two of the cases the chip of steel was subsequently withdrawn by the introduction of an electro-magnet in the direction in which it had been ascertained to lie. The size of one of these bits of steel was practically the same as had been estimated by Mr. Davidson previous to its removal. In another case, the eye being quiet, and two and a half months having elapsed since the injury, operative procedure was not thought justifiable. In a fourth case the eyeball was removed, and dissection showed the foreign body to lie in the position and be of the exact size predicted.

In taking these objects, often very minute, the tube must emit the rays from a small point on the anti-kathode, and the exposure must be short—say a minute to a minute and a half. The method may be illustrated from the following reports of actual cases where extraction was successful:

1. 'A chip of metal situated 3 millimetres external to a piece of lead wire previously fixed to the lower lid, 7 millimetres upwards from it, and 4 millimetres backwards. On working this

out, it led to the conclusion that the foreign body was in the lens, directly behind the discoloured spot in the iris.'

2. 'Diagnosed the presence of a spicule of metal 5 millimetres in length, and located its lower end as situated 5 millimetres inwards, and 4 millimetres upwards, from a lead-wire pointer placed on the lower lid.'

3. 'He was able to diagnose the presence of an exceedingly small chip of metal (less than 1 millimetre in diameter) in the eye. He further located it 5 millimetres above, and 1 millimetre to the nasal side of, a pointer placed opposite a known point on the lower lid, and at a depth of 5 millimetres from the surface of the cornea. These measurements, worked out on the schematic eye, showed the foreign body to be situated in the lens, opposite about the centre of the outer half of the cornea.'*

The advantages of the method in ophthalmic surgery have been excellently summed up by Dr. Collins as follows:

1. They enable us in doubtful cases to determine the presence or absence of a metallic foreign body in the eye. With a good apparatus properly used, a piece of metal less than a millimetre in diameter can be detected in a skiagraph.

2. The exact position in the eye of a foreign body can be located by the method, which allows of the procedure which wil most facilitate its removal to be deliberately planned, so that a minimum disturbance of the tissues of the eye is brought about.

3. The same method allows of the exact size of an unseen foreign body being ascertained, and of the size of the incision necessary for its removal being determined.

4. This method enables us to say whether or not a foreign bod which has entered the eye has passed through it into the orbita tissues or remained in the eye, a point sometimes left in conside able doubt as the result of clinical examination. For example, i is by no means uncommon for a foreign body entering the fron part of the eye to pass through the vitreous, strike the retina, an rebound into the anterior and lower part of the vitreous. In suc a case, if the lens is not wounded, the foreign body may b invisible ophthalmoscopically, and the mark left where it struc the retina be taken for the aperture of exit of the foreign body.

5. The unsuspected presence or the absence of more than on foreign body may be demonstrated. In one case of Mr. Wray

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* *British Medical Journal*, August 20, 1898.

several foreign bodies were shown scattered about in the orbital tissues, the eyeball having escaped injury.

In March, 1897, Benedikt* showed a radiogram of a man who had been injured in the right temporal bone several years previously. Since then his vision had gradually declined, together with the occurrence of retinal detachment. The onset of pain led to a radiographic exploration, which revealed a sharp body penetrating the orbit from the neighbourhood of the zygoma.

The humours of the eye appear to be somewhat resistant to the rays, and the crystalline lens markedly so, while the retina is insensitive to their vibrations.

Calculi in Various Positions

The detection of stones in internal organs, closely connected with the subject of foreign bodies, is likely to become an important branch of radiography. Under present methods, however, results are still more or less uncertain in the case of renal and biliary concretions, and not altogether certain in those of the urinary bladder. For all that, stone has been shown by the radiogram to exist in the gall pouch, in the urinary bladder, and in the kidney of the adult living human subject.

So far as the opacities of the various calculi are concerned, both Neisser and Petersen have demonstrated that while cholesterine concretions are almost transparent, those of phosphates and urates are opaque to the rays. From these premises they concluded that it would be impossible to detect gall-stones by the rays, yet stone in the bladder and the kidney might be thus demonstrated. As already stated, this theoretical conclusion has been more or less upset in practice. Thus, a plate shown to the writer exhibited a faint but unmistakable shadow of a gall-stone. The image was too faint to print, but, as often happens with objects translucent to the rays, could be distinctly recognised on the negative. Such evidence, however, is of value, and, so far as one can judge, is all that is likely to be forthcoming for a time in the case of biliary calculus.

Messrs. Laurie and Leon, in a paper in the *Lancet*, January 16, 1897, published results of experiments showing that calculi of oxalate or of phosphate of lime were more opaque than bone, uric acid of almost the same opacity, and gall-stones very slightly more opaque than flesh. They thus substantially confirmed previous results arrived at by Mr. Henry Morris. Experiments upon gall-stones have been reported by Messrs. Neisser, Goodspeed, and Cattell,* and many others.

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* *Medical Press and Circular*, April 7, 1897, p. 359.

In France Messrs. Chapuis and Chauvel at an early date studied kidney calculus in relation to the rays. They concluded that stones composed of uric acid, urates, and phosphates were little less opaque than bone. Those composed of many layers and of unequal opacity proved by analysis to consist of uric acid nuclei covered with layers containing phosphates. They found the kidney substance less penetrable than muscular tissue, so that the kidney appeared as a light patch on the negative (dark in the print).

In a radiogram of a removed kidney a stone shows as a dark body. Many excellent examples of this sort have been published from time to time.†

To Dr. Macintyre, of Glasgow, belongs the distinction of having obtained the first focus-tube record of a renal calculus *in situ*.‡ It appears that he had failed to demonstrate any concretion in half a dozen cases where stone in the kidney was suspected. Undeterred by these negative results, however, he tried the Röntgen rays upon another patient who had been previously operated upon for the malady in question. Thereupon, with a 6-inch spark and twelve minutes' exposure, he was rewarded by a clear record on a Paget XXXXX sensitive plate. 'In this instance,' to use his own words, 'at the correct situation, a picture of an obliquely-placed elongated deposit was obtained.' From his reading of the result, Dr. Macintyre inferred the presence in the kidney of a stone, but not a well-formed one. The correctness of his inference was subsequently proved by Mr. Adams, of Glasgow, who, on operating, found at the bottom of an old cicatrix an ill-defined mass, which he removed with a spoon.

Messrs. Leon and Laurie, in the paper above referred to obtained a 'faint but distinct image' of a stone introduced into the urinary bladder of a cadaver. They made an exposure o thirteen minutes with a 6-inch spark, the body lying on its back. It is noteworthy that in their experiment the spine itself was very faintly indicated.

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* *Medical News*, February 15, 1896.

† See plate in Morton's '*X*-Ray,' New York, 1896.

‡ *Lancet* for July 11 1896

The same experimenters obtained a record of a stone in the living subject, a boy eight years of age, after an exposure with a 6-inch spark of seven minutes to a XXXXX Paget plate. The stone was removed a few days later with a lithotrite by Mr. Silcock. A collotype of this calculus, which appeared to be a little over an inch in diameter, was published in the *Lancet.* Subsequently another stone was demonstrated in the bladder of a boy of fifteen.

Dr. James Swain, of Bristol, has made some important observations on the subject. He exposed on a single plate various kinds of calculi of nearly uniform thickness to the rays for periods of one, two, four, eight, and sixteen minutes. He found the general law laid down by Röntgen, namely, that the denser the object the deeper the shadow, did not apply exactly to these experiments. Arranged in the order of the highest specific gravity, the greatest permeability to the rays, and the greatest density of the shadow, the results are :

Specific Gravity.	*Permeability.*	*Density of Shadow.*
1. Oxalate of lime.	Biliary.	Oxalate of lime.
2. Uric acid.	Uric acid.	Phosphatic.
3. Phosphatic.	Phosphatic.	Uric acid.
4. Biliary.	Oxalate of lime.	Biliary.

Dr. Swain exposed each of the above kinds of calculi, together with a piece of human rib and a portion of kidney. With each increase of exposure the shadows became fainter, until at length, after an exposure of sixteen minutes, only the oxalic acid and phosphatic calculi, with the merest trace of rib, were to be seen. The important deductions are that a short exposure may give a better result than a long one, and that an oxalate of lime calculus will be much easier to detect than one of phosphates or of uric acid. If the exposure be too long, some of the less dense calculi will disappear altogether.

The uric acid calculus in an eight minutes' exposure gave a less dense shadow than that of rib, and much less, again, than that of a piece of rib covered with kidney. The extreme difficulty of diagnosing uric acid calculi by the Röntgen method is therefore obvious.

Prolonged exposure caused a 'denser' negative. Objects that could not be printed were still visible to the eye. Hence it is always desirable to study the negative to avoid missing shadows not evident in the print. This observation was applied by Dr. Swain to a case where a patient was suspected to have a stone in the kidney. The x-ray negative showed a distinct shadow in the region of the left kidney, but no satisfactory print was obtainable. This result was taken as confirmatory, and a subsequent successful operation removed a stone half as large as a walnut. In this case it is important to note that the shadow given after an exposure of thirty-five minutes was not very deep, but with an exposure of twenty minutes the presence of the calculus was made abundantly clear. In this case the radiograms were taken with a coil capable of giving a spark of 19½ inches, worked at about half its full strength. The focus tube was placed about 12 inches from the body.*

Messrs. F. Taylor and Fripp showed a case at the Clinical Society of London.† An operation had been performed before the x-rays were tried. The kidney was found high up, and as no stone could be felt, it was left unopened. Later a stone high up under the ribs was shown by a Röntgen photograph. A piece of rib was resected a week after the first unsuccessful operation, and an atrophied kidney containing a fair-sized stone was removed.

An excellent case of successful focus-tube photography of a renal calculus has been published by Dr. F. H. Low. The patient was a slight-built youth aged twenty, and the stone, which Mr. Swinford Edwards subsequently removed by nephrolithotomy, was found to weigh nearly 2 ounces.

Dr. Low has kindly furnished the following details: The coil used was a 6-inch, working at a 5-inch spark. Tube of medium resistance and shifting cathode pattern (Watson). Plate, Cadett lightning; development by hydrokinone and metol, subsequently intensified. Distance of tube from plate, 14 to 15 inches. Duration of exposure, seven minutes (much the same result obtained with nine minutes). No precautions taken to restrain respiratory movements.

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* *Bristol Medico-Chirurgical Journal*, March, 1897. † *Lancet*, April 30, 1898.

Alsberg* reported a case where the signs and symptoms of renal calculus left the diagnosis doubtful. The rays, however, showed a sharply-defined shadow, 3·5 centimetres long, 2·25 centimetres wide, between 3 and 4 inches above the crest of the ilium. The presence of a smaller group of stones was also disclosed. A large stone weighing over 2 drachms was subsequently taken from the pelvis of the kidney, while from a calyx at the lower end of that organ a collection of seven small stones was removed. The calculi were of oxalate of lime. In this instance not only was a doubtful diagnosis cleared up, but important indications were also afforded to the operator.

The present position of the Röntgen rays in regard to stone in the kidney and the bladder is distinctly encouraging, and may be illustrated by Dr. Blacker's experiences for 1897 in the x-Ray Department of St. Thomas's Hospital. 'Among the examinations,' he writes, 'included under the heading of medical and surgical diseases were those of suspected calculus, both renal and vesical. Of the former there were seventeen cases, in eleven of which the result of the examinations was negative, although in one case a very large calculus was subsequently removed, and in another a mass of small calculi; in the remaining six an opinion was given that a calculus was probably present, although in no case could it be definitely stated that one existed, so that it would seem that in no doubtful case is it wise to omit the precaution of an x-ray examination. . . . With vesical calculi the stone was clearly defined.'†

The writer has obtained a curious result in a tall stout female patient under his care, who had suffered for many years from an innocent tumour of uncertain diagnosis, apparently connected with the kidney. There were signs of pressure on the gall-bladder, inferior vena cava, and intestines. After many attempts, a diffuse shadow of the tumour showed it to be unconnected with the gall-bladder. At length, with the plate in front of the loin, and an exposure of six minutes with a 12-inch coil, the tube bein 20 inches from the plate, a photograph showing fine detail was obtained. In the absence of the confirmatory evidence afforded by operation, and in view of the great difficulty of interpretation of the radiogram, the author has determined to postpone publication for the present. The tumour could be felt from the front of the loin.

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* *Münchener Med. Wochenschrift*, December 20, 1898.

† 'St. Thomas's Hospital Reports,' vol. xxvi., p. 488.

Mr. Hurry Fenwick applies a specially-constructed fluoroscope to detect the presence of small, deeply-placed stones in the kidney. As a preliminary step, the kidney is brought out on the loin, and the room must be darkened for the screen examination.*

The original of plate 32 was kindly furnished the writer by Mr. Davidson. It shows very clearly a uric acid calculus in the urinary bladder of a living male, twenty-eight years of age. The size of the stone was estimated at 3 to 4 c.m., and its actual diameter when removed by Professor Ogston turned out to be 3·2 cm. The apparatus used was a 10-inch spark coil of Apps. During exposure the patient lay on his belly, and a remarkable print of the scrotum appears on the plate. This phenomenon is attributed by the operator to the moisture of the parts having penetrated the two folds of sateen cloth which covered the plate and moistened the gelatine film so that the cloth slightly adhered to and impressed the film. To obviate similar occurrences, which he had noted more than once, he has since used waterproof paraffined paper for covering the plates. It is open to some question if this interesting phenomenon is quite so easily explained, for warmth, pressure, and electrical action might be one or all involved.

In the foregoing case the patient, as already stated, was on his belly, so that the stone, which lay loose in the bladder, was brought near the plate. The rays were then passed obliquely through the lower outlet of the pelvis, so as to fall obliquely on the recording surface, the tube being placed below the buttocks. In children, and also in suitable cases in adults, a good result can be obtained by placing the focus tube close to the sacrum, with the patient on his face, and taking the photograph through the pelvis.

It seems tolerably certain, then, in the light of what has been already done in this important branch of surgery, that the demonstration of all internal calculi of any size in the adult will sooner or later be within the power of the Röntgen ray operator. At present it is difficult or impossible to obtain any

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* *British Medical Journal*, October 16, 1897.

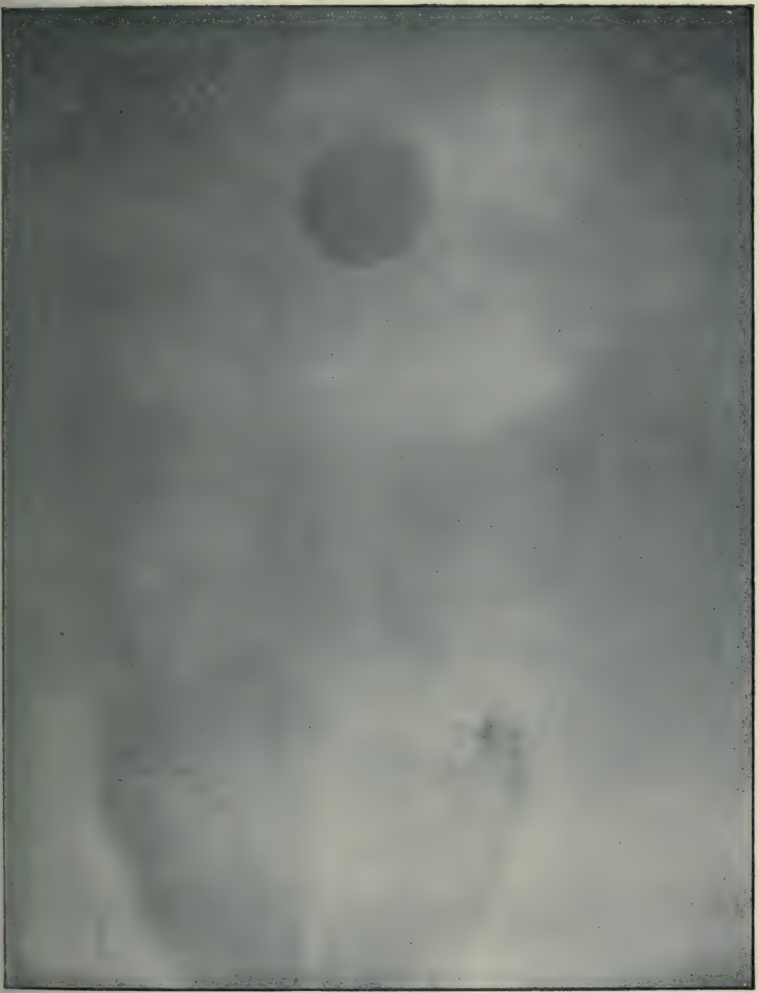

PLATE III.—STONE IN BLADDER.

M. Davidson, M.B. *To face p.* 122.

satisfactory results in the case of stout persons, and the operator who undertakes such cases must be prepared for disappointment.

II. BONES

(*a*) General Remarks

The following experiment was devised by the author with a view of ascertaining to what particular element of bone the Röntgen ray shadow of bone was due. Three small bones were taken from just above the hoof of a sheep; the first was left in its natural condition, the second decalcified by soaking for several days in dilute hydrochloric acid, and the third calcined in a furnace. The three bones thus prepared were placed side by side on a sensitive plate, and subjected to the rays, with the result reproduced in Fig. 75. The normal bone on the left affords a standard for relative comparison; the centre or decalcified one casts a much fainter shadow; and the calcined one on the right yields a photographic record as dark as the normal bone, but sharper and clearer in detail. It should be noted that the process of decalcification was not completely carried out, so that some of

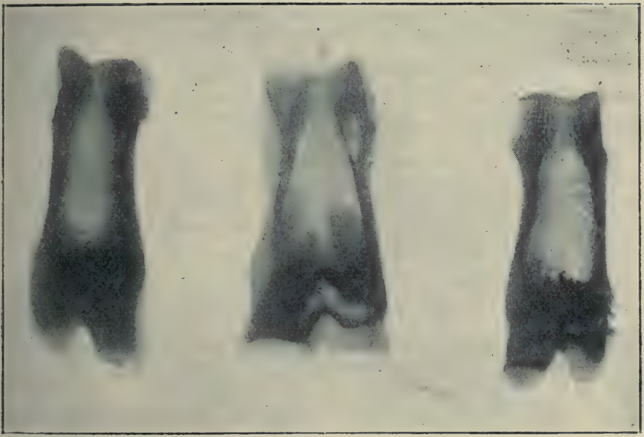

FIG. 51.—THREE SMALL BONES FROM FOOT OF SHEEP: ON LEFT, NORMAL; IN CENTRE, DECALCIFIED; ON RIGHT, CALCINED (AND CRACKED BY THE HEAT).

the shadow in the centre bone, especially in its lower portion, is doubtless due to lime salts that have not been entirely removed by the acid. This simple experiment seems to show that the main part of the shadow thrown by bone is due to its contained lime salts.

The opacity of bone to the Röntgen rays is much greater than that of the neighbouring soft tissues—a fact doubtless due to the earthy matters which form three-fourths of osseous structure. This quality enables us, by means of the 'new photography,' to obtain a sharply-defined shadow of most of the bones of the human body. Where the latter lie in a single layer, and the soft parts around are comparatively thin, as in the hand, a record can be quickly obtained upon either the screen or the sensitive plate. But in the pelvis, where the parts are thick and the bones more or less overlapping, the resulting photograph is obscured. In the case of the head, each half of the skull is more or less recorded on the plate, so that a blurred picture of double shadows results. For all that, the surface next the plate is always the more sharply recorded, so that indications of the utmost value are often obtainable from Röntgen ray examinations both of skull and of pelvis.

Bone being relatively opaque to the rays, it follows that any break, whether in continuity or in outline, and any abnormal position in relation to joints, will be readily detected by means of the Röntgen methods. As a matter of fact, not only are fractures and dislocations indicated in this way, but also many other pathological states, such as exostosis, caries, altered density, and the formation of callus. The surgeon, indeed, when called upon to deal with injuries and diseases of bone, will find himself furnished with an entirely new weapon of accurate investigation. Instead of long and painful manipulations, often ending in nothing better than a suspended judgment, he will in many instances be able after an appeal to the rays to give a definite diagnosis and prognosis. Such results, it should be noted, may be obtained without causing the patient a moment's additional pain, and without taking off splints (if non-metallic), bandages, or dressings that may have been applied.

In order to read his results aright, the surgeon should make himself familiar with the radiographic appearances of bone, both in a healthy and in an abnormal state. A workman's hand, injured many years previously in a machine accident, is portrayed in Fig. 53. The hand, it may perhaps be pointed out, is the right, and not the left, as might be at first imagined by anyone unfamiliar with the process. The reason is that the photograph is taken by transmitted and not by reflected light, so that we have on the sensitive plate the record of a shadow, and this is reversed in the process of printing. Owing to non-recognition of this fact by the surgeon, the wrong hand is said to have been actually operated upon. Healthy bone appears as a dark shadow with a more or less well-defined outline, and where it is thinner and more spongy, as in the bosses projecting sideways from the distal ends of the metacarpals, and in the small sesamoid bone below the metacarpo-phalangeal joint of the thumb, the image is fainter. The joints are indicated by clearly-marked light intervals between the bones, where the rays have penetrated the intervening articular cartilages.

A point worthy of passing notice is that the sesamoid bones of the hand often show as well-defined spots, the size of small shot, through the distal portions of one or more of the metacarpal bones. In that position they have been mistaken at times for a pathological condition. The sesamoid over the metacarpo-phalangeal joint of the thumb is usually taken in profile, and, falling clear of the thumb-bones, presents a sharp picture. Dr. Clendinnen, of Melbourne, has published a Röntgen photograph of the mummied hand of a nobleman's wife, aged twenty-five years, entombed at Memphis B.C. 1500.* No less than five sesamoid bones are shown—one over each of the metacarpo-phalangeal joints of the index and little fingers, two at the metacarpo-phalangeal joint of the thumb, and one over the ungual phalanx of the thumb. As to the last-mentioned, Professor Allen states that he has never found or heard of a similar abnormality in modern skeletons. A number of instances of the kind, however, have been collected and brought to the writer's notice by Mr. Frederic Fenton.

As to the abnormal hand, Fig. 53, the reader will do well to study it carefully in detail. The phalanges of the three remaining fingers are enlarged and dark, while the usual gaps between the end joints of the middle and ring digits have disappeared. The most likely reading of these recorded facts is that the fingers have been affected with chronic osteo-arthropathy, which has enlarged the bones and obscured or obliterated some of the joints. As regards pathological conditions, the following appear to be probable :

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* *Intercolonial Medical Journal of Australasia*, February 20, 1898, p. 106.

1. Old greenstick fracture (thumb metacarpal).
2. Malunited fracture (right angle, second metacarpal).
3. False joint (this may possibly be bony union ; third metacarpal).
4. Impacted fracture (bony union, fourth metacarpal shaft).
5. New articulation (fourth metacarpal base).
6. Bony anchylosis (distal end fifth metacarpal and first phalanx of fourth).
7. Fibrous and partially osseous anchylosis (base fourth and fifth metacarpals).
8. Dislocation (multiple, carpus).
9. Compensatory curving of bones (twisted index-finger).
10. Bone hypertrophy (various bones).
11. Obliterated joint (terminal joints second and third fingers).
12. Arrested development of distal epiphysis of first phalanx of middle and ring fingers.

One or two of the above explanations, especially in the absence of a careful examination of the hand itself, are perhaps somewhat open to an alternative reading.

(*b*) **Fractures and Dislocations**[*]

It is in these injuries, especially when obscure, that the Röntgen methods render invaluable and often brilliant results. For example, they are available when the surrounding parts are too swollen to admit of examination by ordinary methods, or when the manipulations of the surgeon cannot be borne by the patient.

The objection has been made by some surgeons that the rays reveal nothing that could not be equally well learnt by other methods. To this it may be answered that not a few bone injuries occur in which it is impossible for any man, however skilful, to make an exact diagnosis—at one time, it may be, owing to the swelling and tenderness of parts, and at another to the obscurity of the signs. Under such adverse circumstances precise evidence may be obtainable forthwith from the Röntgen screen or photograph. Moreover, the gain of this particular form of investigation does not end with recovery. In cases of accident likely to come before a jury, the proof afforded by a photographic record of a bone condition may one day win a civil action, or vindicate the scientific reputation of the medical attendant, two points that will be referred to again under the heading of jurisprudence. Further, if the progress of a fracture be unsatisfactory, the surgeon can hardly be doing his duty either to himself or to his patient if he neglect the possible assistance to be gained from a Röntgen photograph. Some medical men scout the idea of calling in the services of a professional photographer to help them in arriving at a diagnosis. If that line of reasoning were sound, it would equally prevent physicians from weighing a patient because the scaling chair is the work of a professional balance-maker. In a similar way it would preclude them from sending throat secretions to a biological laboratory to be tested for the presence of the diphtheria bacillus, or from using the microscope, the stethoscope, the phonendoscope, and the rest of the hundred and one aids to accurate investigation sold by the instrument-makers.

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[*] This section has been kindly revised by Mr. Lynn Thomas, F.R.C.S., of Cardiff.

The surgeon should bear in mind that iodoform, bismuth, and some other metallic dressings are opaque to the rays, as well as lead lotion and the various kinds of adhesive plaster that have a lead basis; but we have it on the testimony of the medical department of the Soudan Expedition that, although such effects injure photographic results, they do not seriously impair the evidence afforded to the surgeon.

Splints made of felt, pasteboard or wood are translucent, while those made of metals, except aluminium, are of course opaque. Plaster of Paris is dense, but a photographic record can be obtained through such a splint by using a focus tube of high penetration; in which case the resulting photograph is apt to be mottled and patchy, owing to the varying thickness of the plaster. A good substitute for plaster is the handy 'water-glass' or silicate of sodium splint, which is translucent to the rays, and may be used conveniently where it is intended to take a Röntgen photograph during the progress of any particular case.

Nowhere is the necessity for comparative photographs more evident than in the case of obscure fractures. A slight peculiarity of the individual bone may be exaggerated into a pathological guise by the peculiar relative position of the tube, by the rays falling obliquely on the plate, or by an awkward attitude of the patient. In one case of alleged old-standing fracture of the external condyle of the humerus, the reading of the Röntgen photograph itself, without another of the sound elbow taken under similar conditions, became a matter of pure conjecture.

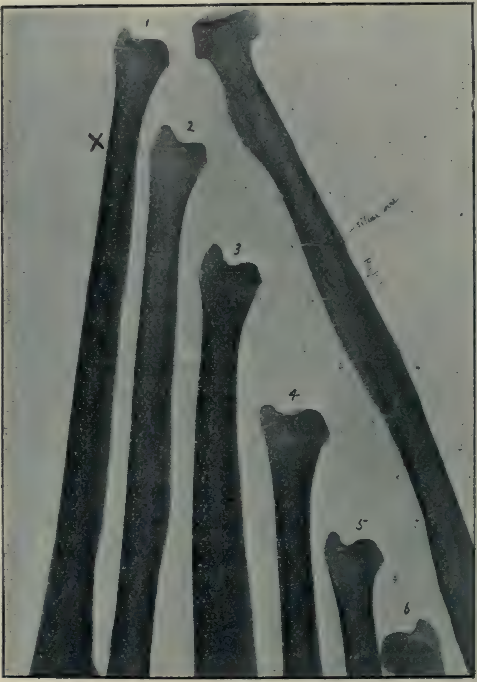

FIG. 52.—LYNN THOMAS'S DISTORTION EXPERIMENT.

(Six specimens of ulnæ with the bases of their styloid processes sawn through, but not detached, with a fret-saw. On the right is a radius with six fissures, made by the same fret-saw, through its ulnar margin.)

A fracture may not be shown on the plate because the *x*-rays have not hit the gap in the bone in their straight passage from the anti-kathode to the sensitive plate. Then the break itself may be oblique, and thus interpose overlapping edges of bone

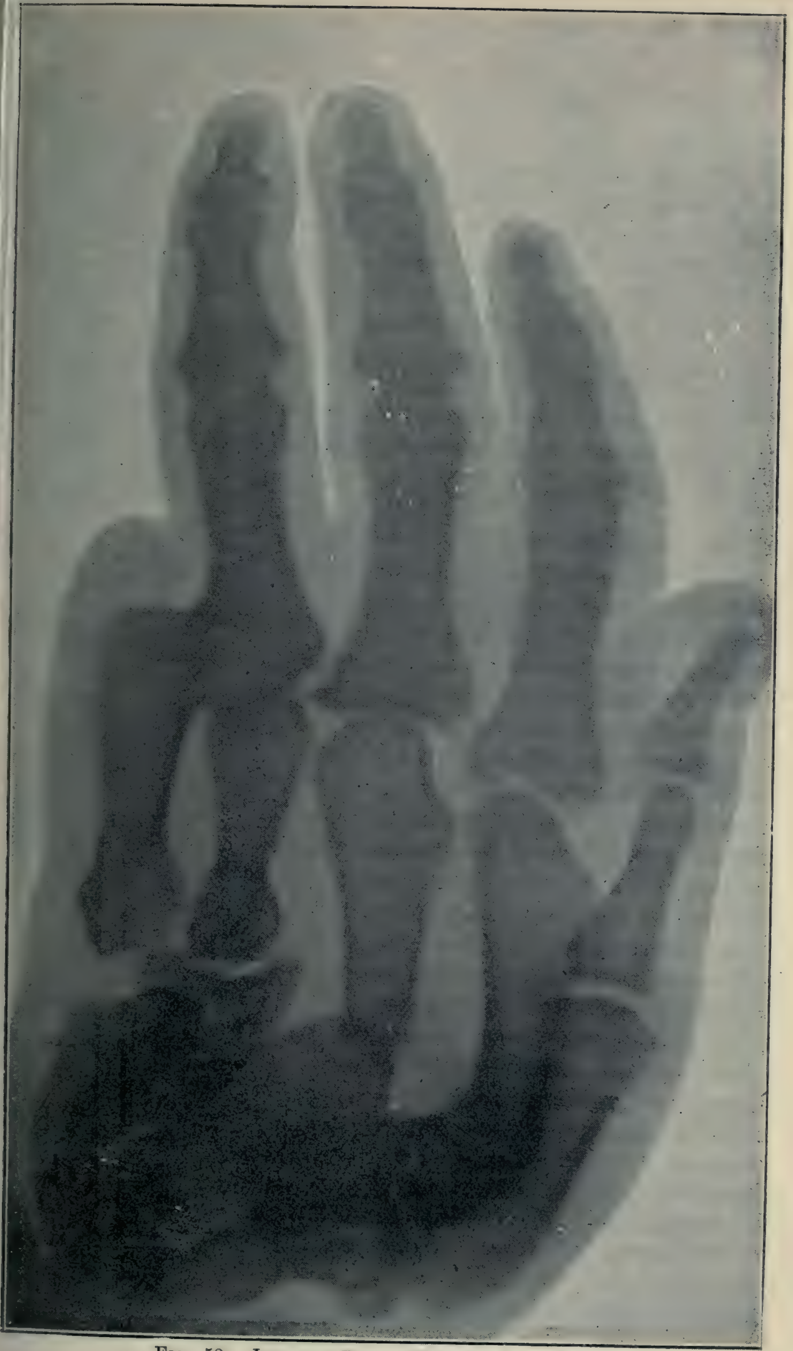

FIG. 53.—INJURED RIGHT HAND OF WORKMAN.
By Mr. Greenhill.

between the source of the rays and the photographic surface. Mr. Lynn Thomas described an instructive experiment at a meeting of the Röntgen Society, May 1, 1899. He made parallel saw-cuts through the styloid processes of several ulnæ, and several more cuts into a radius. The anti-kathode was fixed by means of a plumb-line directly over the second ulna, counting from the top downwards (see Fig. 52). The long axis of the tube ran parallel to the radius shown in the illustration. The latter bone was also incised with a saw, and loops of wire twisted from the bottom of each saw-cut round the sound part of the shaft. The result is striking. The two upper cuts in the ulnæ show as unmistakable gaps. The next is less complete; while in the lowest one no change is visible in the bony substance. At the same time progressive distortion is shown in the shape of the ends of the ulnæ. The radial incisions become more and more **V**-shaped from above downwards, and the wire loops more and more oval.

The anti-kathode of the focus tube on the Röntgen lamp was placed over the point **X**—*i.e.*, perpendicular to the base of the styloid process of No. 2 ulna.

It will be observed that the fissure is more or less obscured by the shadow of the edges of the crack as we advance towards No. 6. If we add, in fancy, the shadow cast by the soft tissues upon this photograph, I feel quite sure that no unbiassed radiographer would accept the evidence as indicating a fracture. The different ulnæ have different density to the *x*-rays, owing to the different ages and sexes from which they were obtained.

In the radius we have a good example of the distortion a straight crack or fissure is liable to undergo by the position of the anti-kathode. The density of the adjacent edges of the compact bone of the radius—which, by the way, is nearly triangular in shape at the line of the fret-saws—is enough to allow a photograph of the two surfaces of the fissure—*i.e.*, the one next the plate and the one next the Röntgen lamp—to appear distinctly. The result is a **V**-shaped light line with limbs of varying lengths. The angle of the **V**, as well as the limb of the **V** which is caused by the shadow of the crack furthest away from the plate, can be increased or diminished according to the operator's wish, or converted into a straight line.

This experiment clearly shows the confusion and distortion due to varying relative positions of object of tube and of plate. It strengthens Mr. Lynn Thomas's plea for a standard point in the centre of the wrist in examining injuries of that region. At the same time it must be borne in mind that the break is not always in the nature of a vertical separation, but often runs obliquely. The only trustworthy way of examining for fracture is by the use in the first place of the screen at various angles. This fact can be verified by five minutes' careful examination of an old Colles' fracture. By moving the arms up and down and from side to side the injury and the shape of the bones may be made to assume a variety of appearances.

It seems likely that the Röntgen rays will help towards a truer conception of what really takes place in some particular injuries, such as Colles' fracture of the lower end of the radius (see Figs. 56, 57, 58).

Of late a good deal has been heard of the practice of wiring recent fractures, such as those of the olecranon, lower end of fibula, patella, and of other bony parts where union is commonly delayed or vicious. Under the conditions of modern surgery the plan appears to offer in many cases a good prospect of securing rapid and bony union. It need hardly be added that the procedure consists in cutting down under antiseptic or aseptic precautions upon the broken ends, which are then drilled obliquely and brought together by stout silver wire. In this particular class of cases the surgeon will learn from the rays—(1) whether wiring is advisable, (2) whether proper apposition has been secured, (3) whether bony union has followed.

The plan of 'nailing' recent fractures of the condyles of the humerus, or of a loose fragment of bone, as advocated by some surgeons, would in many instances be hardly feasible without a clear knowledge of the condition of the broken bone, gained from a screen examination or a radiogram. In the method of treating false joints or malunited fractures by 'Lane's screws,' a Röntgen photograph is of the utmost value in assisting the surgeon to determine before operation the exact length of the screw required in each particular case. By uniting fractures of the leg-bones (such as Pott's) by screws that are too long, serious damage can be inflicted on nerves or bloodvessels unless the surgeon avails himself of the aid of the x-rays. The accompanying figure (54) shows that the screw used was of the right length

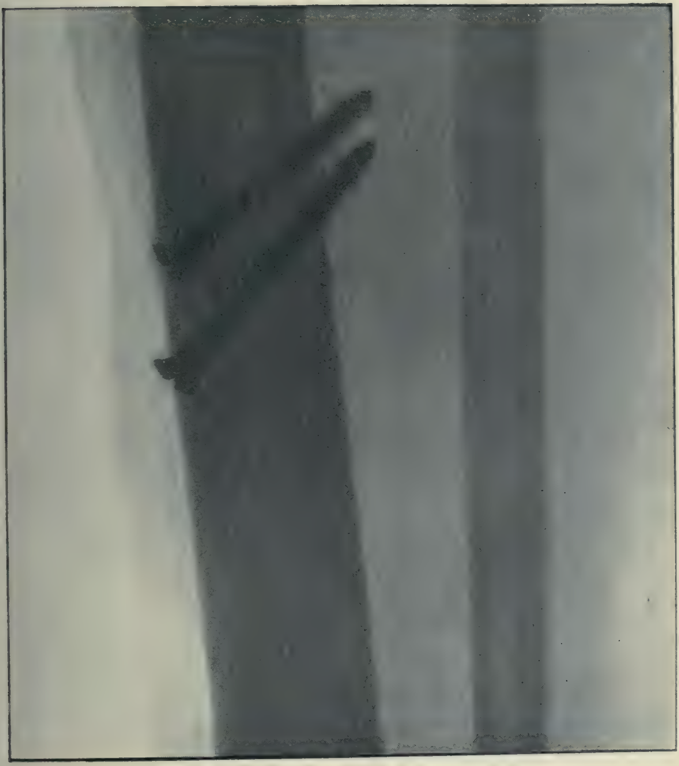

Fig. 54.—Screws in Tibia.
Lynn Thomas, F.R.C.S.

[*To face p.* 130.

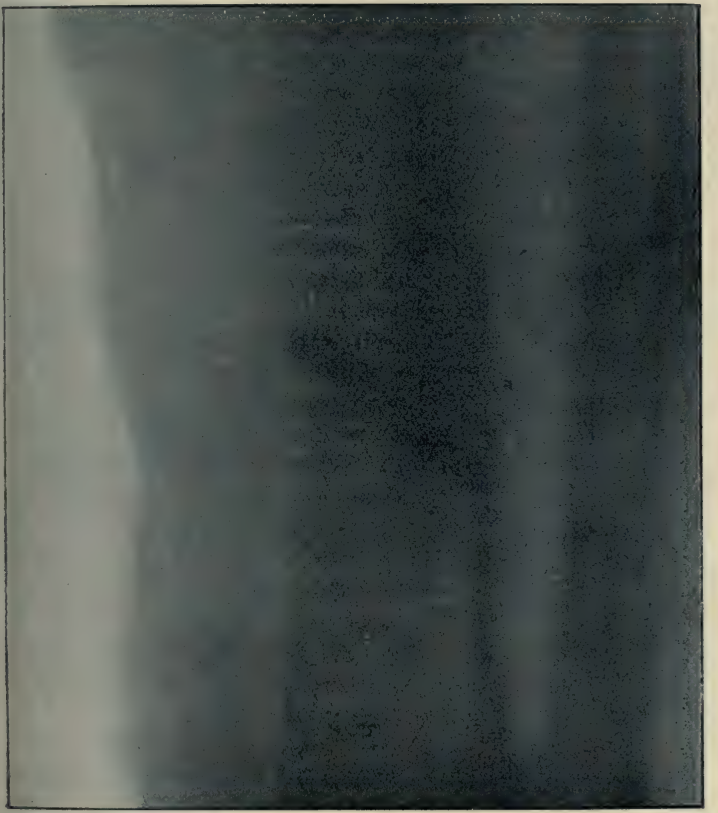

FIG. 54.—LANE'S SCREW IN TIBIA. The uneven outline is due to the bandages.

Mr. Lynn Thomas.

and that the mechanical adaptation of the tibial fragments was satisfactory. Some of the remarks made about 'screwing' apply also to 'wiring' and 'nailing.' Again, the 'screwing' on of a loose fragment offers a promising field for treatment. An excellent case in which sound union of a fractured olecranon was secured in this way was published by Mr. Thomas Moore, F.R.C.S.*

Where a fracture is attended by such complications as impaction, comminution, multiplicity, interposed tissues, extension into a joint, or dislocation, Röntgen methods afford most useful information. The practical value of the method, however, extends beyond diagnosis, for by further investigation it can be ascertained whether the bones have been reduced to proper position, and whether sound bony union has followed. The progress of a fracture can be followed readily enough when the splints and dressings are translucent to the rays. If it be desired to make periodical examinations through a fixed apparatus, the splints, as already stated, must be made of some penetrable material. The separation of epiphyses, or the so-called 'fracture through epiphyses,' a subject of great importance in surgery, will be dealt with in a separate section (see p. 152).

Where a fracture has ended in fibrous union, false joint, or other imperfect result, the exact state of affairs can, with one or two exceptions, be readily found out by the radiogram. A similar remark applies to a stiff joint after dislocation or other injury. In all these cases important indications may be gained as to the appropriate form of treatment, whether by resection, osteotomy, wiring, refracture, or the breaking down of adhesions.

The exceptions above referred to are chiefly those of fracture or dislocation, or both together, about the shoulder or the hip. In each case an antero-posterior view may be obtained, but a lateral view is rarely of any use, owing to the multiple shadows of superimposed bones. Thus, the absence of the bone from its socket can as a rule be readily demonstrated, but no lateral record is available to show whither it has gone. Under these circumstances, we fall back upon our exact localizing processes, and by a double photograph determine the exact position of the displaced bone.

The diagnostic application of the *x*-rays, it may be observed, is likely to do away with much of the time-honoured business of the bone-setters. As Mr. Howard Marsh and others have pointed out, the greatest successes of those irregular practitioners have been scored in nine cases out of ten by the forcible rupturing of arthritic bands. It is now open to everyone to put to an absolute test by means of the Röntgen rays the bone-setter's stock assertions that 'the joint is out of place' or 'the bone not properly set.' In this unexpected way, it is interesting to note, science has cut away the ground from under the feet of the charlatan. Professor Röntgen's discovery has thus dealt the bone-setter a deadly blow that ages of scientific protest have failed to accomplish.

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* *Archives of the Röntgen Ray*, July, 1897.

A curious condition of affairs is shown in Fig. 55. The original was taken by Mr. Gerard Peck, of Scarborough, and kindly placed at the writer's disposal. The patient was a woman sixty-two years of age, who injured her arm by a fall. Pain was felt at the time, but, curiously enough, the fracture was not detected for some months. The patient was dressed by her daughter, and is reported not to have noticed the deformity until she one day saw it reflected in a mirror.

The photograph was taken with a Tesla set capable of giving a 2-inch spark, and an exposure of two minutes. It reveals a fracture of the lower end of the forearm, united at an extreme angle, with a V-shaped forward bend.

An instance of the value of the diagnosis of adhesions is afforded by the case of a patient who suffered from a locked wrist, and the radiogram showed there was no disease of bones. This result pointed by a process of exclusion to the presence of interarticular bands, and indicated a successful line of treatment.

To sum up: in dealing with bone injuries successful radiography, compared with previous methods, offers the following advantages: It substitutes speed, accuracy, and finality, for delay and doubt; it affords exact evidence that may confirm or modify the diagnosis of the surgeon; it may furnish both grounds for prognosis and hints for treatment; it may save the patient the pain of useless, and perhaps, dangerous, manipulations, as well as the shock of anæsthetics; it provides a permanent record of the precise nature of an injury; it may prove a safeguard for the patient and for his medical attendant, both in the present and the future; and, lastly, it can hardly fail to be of value for teaching purposes.

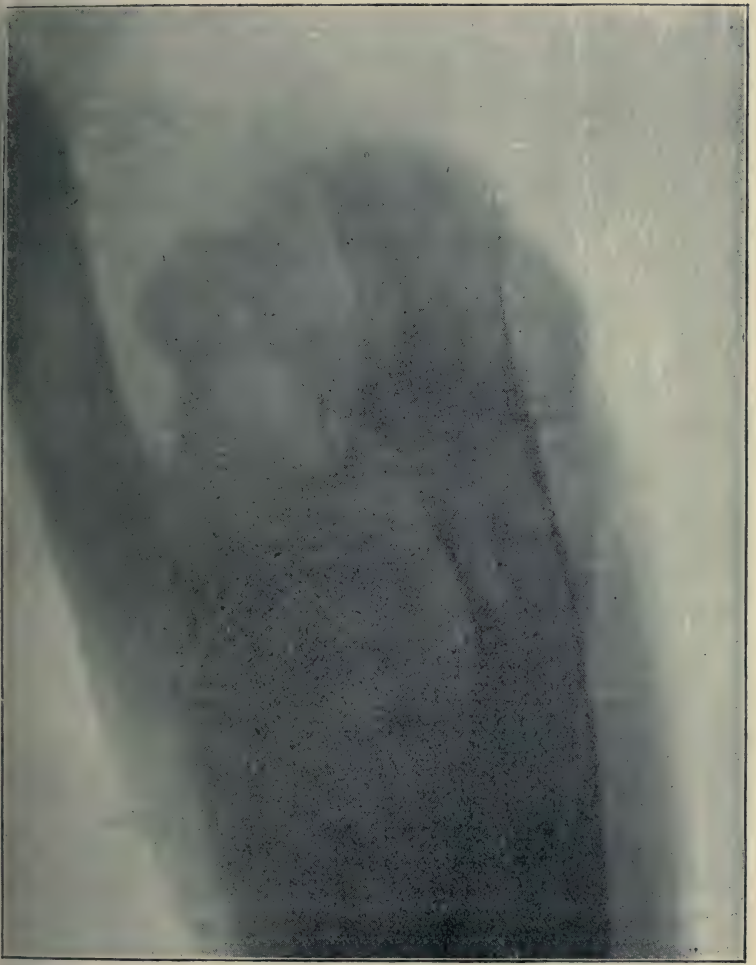

FIG. 55.—FRACTURE OF HUMERUS UNITED WITH A FORWARD V-SHAPED BEND. By Mr. Gerard Peck, Scarborough. Natural size.

(In taking the original of the above block, the apparatus broke down after two minutes' posure. The picture, however, proves how a readable record can sometimes be procured nder adverse circumstances, as it was taken in the days of long exposures.)

Special Fractures

Fractures of the scapula that may be detected by ordinary manipulation need not be considered here. Sometimes, however, an injury of the kind is exceedingly obscure, in which case a Röntgen ray examination might disclose its real nature. For instance, it would be difficult or impossible in any other way to diagnose the rare fracture of the glenoid cavity from dislocation of the head of the humerus or fracture of its anatomical neck.

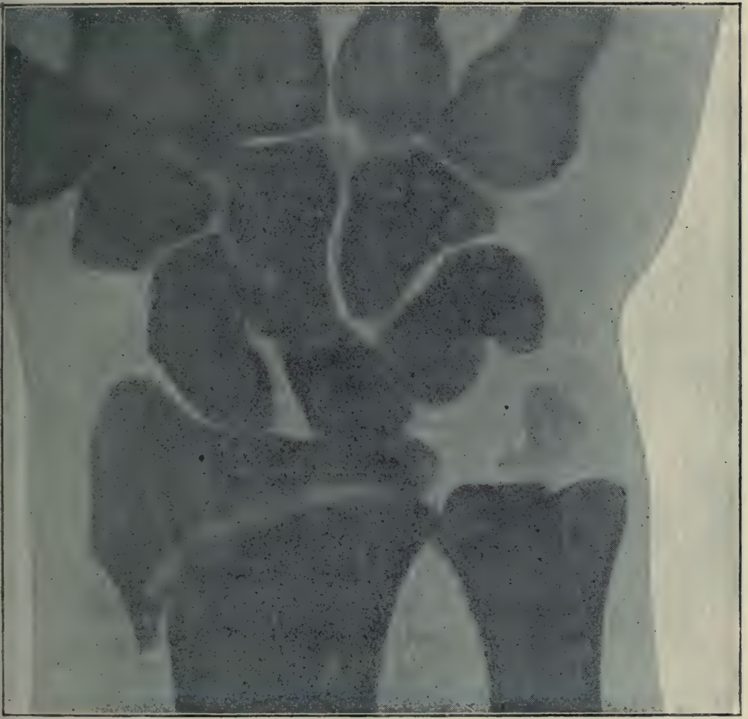

Fig. 56.—Double Colles' Fracture showing Ordinary Fracture of Radius with Outward Displacement, and Fracture of Styloid Process of Ulna. Mr. Lynn Thomas. Natural size; see also Fig. 57.

Fractures of the collar-bone can be readily shown by the rays but as a rule there is little information to be gained in that way that could not be acquired by simpler methods of examination.

An exception may perhaps be made in the case of the break without displacement that sometimes occurs between the attachments of the conoid and the trapezoid ligaments. Such a case was reported by Dr. Richardson:* 'A football-player of nineteen injured his left shoulder. Six hours after the accident tenderness was found at the outer end of the clavicle, but neither crepitus nor deformity was to be made out. The Röntgen rays showed a solution of continuity at the point of tenderness, where a week later callus appeared.'

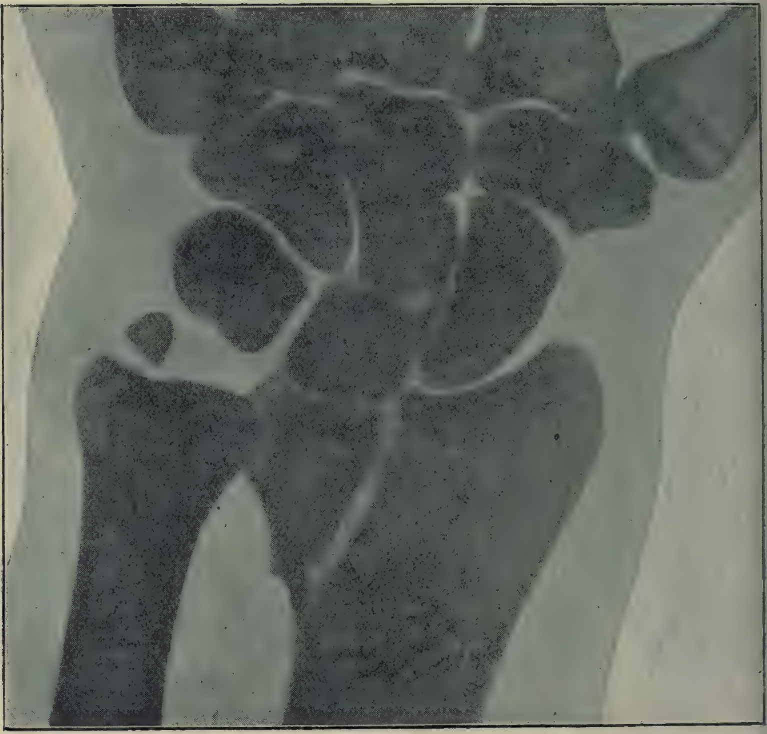

FIG. 57.—DOUBLE COLLES' FRACTURE SHOWING LONGITUDINAL FRACTURE OF RADIUS WITH SLIGHT IMPACTION, AND FRACTURE OF STYLOID PROCESS OF ULNA.

Fracture of the Humerus.—This bone is readily photographed throughout its length by the Röntgen methods, which are of special value in determining the nature of obscure injuries at its upper and lower ends. The exact diagnosis of fractures about the head, as every surgeon knows, is often attended with great, if not insuperable, difficulty, especially when there is much swelling. Incomplete separation of the head of the humerus at its junction with the shaft has been reported in cases that had been regarded as sprains before the Röntgen examination, and it seems not unlikely that such injuries may prove less rare than has been hitherto suspected. So, too, fissures due to direct violence have often been observed in cases which, were it not for the Röntgen rays, would have been classified as bruising of the soft tissues. In a case under Mr. Lynn Thomas, a comminuted fracture of the surgical neck, it would formerly have been impossible to make out the precise nature of injury.

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* *Boston Medical News*, December 26, 1896.

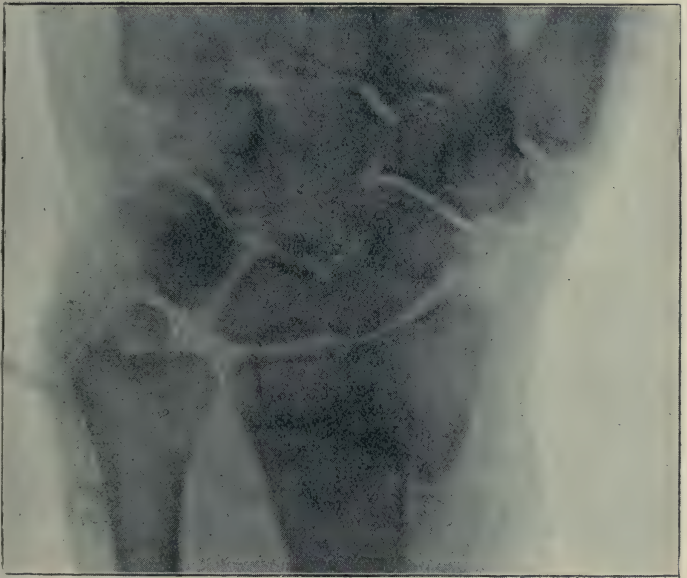

FIG. 58.—COLLES' FRACTURE, WITH RUPTURE OF RADIO-ULNAR LIGAMENT.

Fractures about the elbow are often attended with such rapid swelling that, unless seen at once, it is in many instances impossible to ascertain the extent of the injury for several days. Indeed, it is hardly too much to say that under such circumstances a Röntgen photograph of the swollen elbow is absolutely the only means of exact diagnosis at the command of the surgeon, who may in this way save much valuable time and anxiety. For instance, the damage may be of such a kind as to demand prompt excision. In any event, the x-rays will indicate whether the line of fracture at the lower end of the humerus is (a) transverse, (b) T-shaped, (c) through condyles, (d) through epiphyses, and whether it is complicated by (e) dislocation or (f) fracture of the olecranon. In this way the surgeon can inform the patient forthwith as to the probable duration and result of treatment. Moreover, from the knowledge gained as to whether the fracture is extra- or intra-capsular, he will know exactly when to begin and when to avoid early passive movements. Thus, if the break be transverse, above the capsule, such exercise can be delayed for a month or more, 'as there is then no danger of a stiff joint, but a risk of the passive movements at the seat of fracture leading to a false joint' (Walsham). Other authorities would, however, with Lucas Championière,* advocate immediate massage, together with mobilization. Indeed, the advantages of the new method to the practical surgeon are nowhere more apparent than in obscure injuries to the elbow-joint.

Fractures about the middle of the forearm are readily accessible to the rays, the information derived from which may be applied upon general principles. However, so far as the pathology of fracture of the lower end of the radius is concerned, the method has already demonstrated a number of fresh facts. Mr. Thomas† published the instructive case of a patient with double Colles' fracture. From a clinical point of view the lesion appeared to be identical on both sides, but the Röntgen photographs showed a wide difference in the bone injuries. In each the styloid process of the ulna was fractured at its base, an event usually described by surgical authorities as somewhat rare. One wrist (Fig. 56) showed the ordinary fracture of the lower end of the radius, with outward displacement; the other (Fig. 57) slight impaction of the radius about three-quarters of an inch from its lower end, to be detected by noticing the irregularity on the ulnar side of the bone. By the side of and near that projection is a 'complete longitudinal single fracture of the lower end of the radius, showing a detached portion of a triangular shape in its normal position attached to the radio-ulnar ligament.' In a later communication to the same journal, the author expressed an opinion that 'the true pathology of one of the commonest of fractures (*i.e.*, Colles') requires rewriting in the leading surgical text-books in the English language.' In 1899, thanks to the *x*-rays, one can state that fracture of the ulnar styloid process usually accompanies injuries to the radius in Colles' fracture.

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* 'Traitement des Fractures par le Massage et la Mobilisation,' 1895.

† *British Medical Journal*, January 2, 1897.

Mr. Thomas has placed a third record (Fig. 58) at the disposal of the writer. In his opinion, this illustrates the rupture of the radio-ulnar ligament described by Mr. Clement Lucas in Guy's Hospital Reports for 1884.

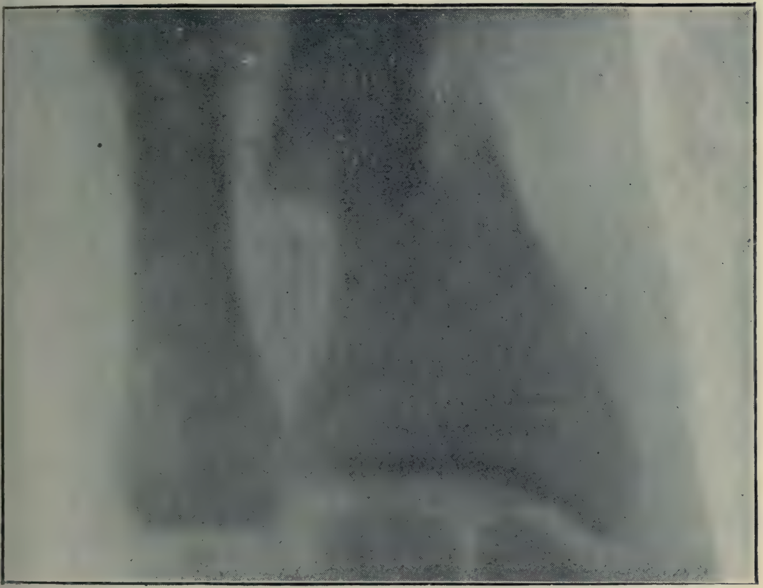

FIG. 59.—DOUBLE FRACTURE OF FOREARM, SHOWING DISPLACEMENT; GRAIN OF WOODEN SPLINT PLAINLY SHOWN.

The illustrations shown in Figs. 59 and 60 furnish a good example both of fractured forearm and also of the service that the Röntgen rays can at times afford in surgical practice. They were taken from a restless and muscular young man, eighteen years of age, under the care of Mr. Jonathan Hutchinson, junior, at the London Hospital. The patient presented himself with a broken arm, which had been put up in splints a few days before at another institution, and which he imagined was not going on well. A Röntgen photograph, not here reproduced, proved double fracture, with both bones in perfect alignment. When he returned a week later, the rays revealed considerable displacement (Fig. 59).* The broken bones were thereupon readjusted, but at the end of another week the fragments were again found to be overriding (Fig. 60). The limb was reset, and ten days later the x-ray record showed union in good position, almost, but not quite, equal to that demonstrated in the first photograph.

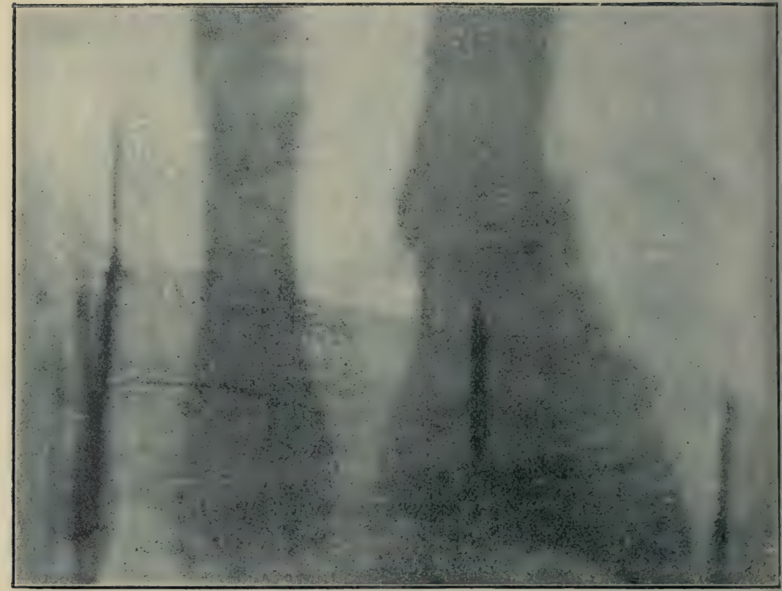

FIG. 60.—DOUBLE FRACTURE OF FOREARM, SHOWING DISPLACEMENT. The dark shadow athwart the lower fragments is due to adhesive plaster. Mr. Greenhill.

In the after-treatment of a restless patient, then, the Röntgen methods may prove of constant value. Even if the results of such an examination be negative, no harm will have been done, as it can be conducted without taking off a single splint, dressing, or garment. By availing himself of its aid, the surgeon may possibly avoid consequences dangerous alike to the welfare of his patient and to his own reputation.

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* The photographs were taken through splints and clothing. In the first the grain of the wooden splint can be traced.

Destot* has described fractures of the scaphoid, os magnum, and styloid process of the ulna, associated or not with fractures of the radius. Of the latter, he has identified with the fluoroscope three chief types: (1) The epiphysis is entirely detached, and, strictly speaking, there is no interarticular fracture. (2) The fragment is wedge-shaped at the expense of the posterior aspect of the radius, the front of which retains its position. This type shows many varieties, as when the fragments are multiple or displaced from without inwards, when the fissure extends higher or lower, involving the posterior lip only, or the epiphysis only. Special attention was drawn to this particular kind of fracture in the pre-Röntgen-rays day by Dr. Rhea Barton in 1838,† and Hamilton, in his treatise on Fractures and Dislocations, designates it 'Barton's fracture' in contradistinction to a Colles' fracture. It is interesting to observe that many pathological conditions of bone lesions, which were hitherto known only to a few experts, have been again prominently brought before the notice of the profession from observations made by means of the x-rays. It is always advisable to radiograph obscure bone injuries, and not to trust the fluoroscope alone, because the former method will record what the eye cannot see in the latter: the one is like counting the stars of the Pleiades with the naked eye, and afterwards comparing notes with a photograph of the same region. (3) The anterior and posterior lips are broken off, and the shaft penetrates them, separating the one from the other, the bones being all more or less comminuted and more or less displaced on the outer side.

Destot points out several possible fallacies connected with the examination of the wrist. The shadows of the bones do not exactly correspond with the appearance on a skeleton; one may confuse a dislocation of the first row of carpal bones with a fracture of the os magnum. The scaphoid, instead of being boat-shaped, may present a globular form, crossed by a shadow, and due to a subluxation. Fracture is present only when a clear space separates the two fragments.

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* 'Radioscopie Clinique,' Régnier, p. 54.

† *Philadelphia Medical Examiner*, 1838.

Fractures of the hand can be readily demonstrated by means of the Röntgen rays. A break of the fourth metacarpal, not an uncommon injury, is sometimes difficult to diagnose by ordinary methods. An x-ray examination would at once reveal an injury of that kind, and has often disclosed simple longitudinal fissures in bones said to have been bruised. In the case of the Poor Law Medical Officer, who is paid on a higher scale for attending fractures, the possibility of proving the existence of such obscure injuries presents a distinct economical advantage. To a less extent a similar remark applies to all who are engaged in surgical practice, whether special or general.

The illustration portrayed in Fig. 61 shows the results of a cogwheel accident fourteen years previously. The metacarpal bone of the forefinger has been apparently broken into two main pieces, which lie at a cross-angle of about thirty degrees. The irregular shape of the lower fragment probably results from chronic periostitis and osteitis following the injury. Between the two fragments there appears to be a kind of false joint. The middle joint of the forefinger is partly obliterated by what seems like bony union. The sesamoid bone opposite the distal end of the thumb metacarpal has apparently become united to the latter by a more or less ossified ligament. The original photograph, kindly lent to the writer by Dr. J. R. Philpots, of Parkstone, shows some good records of muscles and other soft structures. Thus, in the outer side of the little finger metacarpal may be traced the abductor and flexor brevis muscles. On the outer side of the middle joints of the second and third fingers are what appear to be the lateral expansions of the common extensor of the digits. Along the back of the bones of the metacarpal and phalanges of the thumb the extensor tendons can be clearly traced. The tendon of the extensor secundi internodii, indeed, can be followed up to its insertion at the base of the terminal phalanx. Unfortunately, most of these results are lost in reproduction.

In fractures about the pelvis the Röntgen rays, so far as one can judge, are not likely to help the surgeon much. The hip, again, is deeply placed, and so far satisfactory results are not always attainable. However, much is often to be learnt in the case of children and young adults, in one case a fracture of the neck of the femur was shown in a muscular adult, six feet in

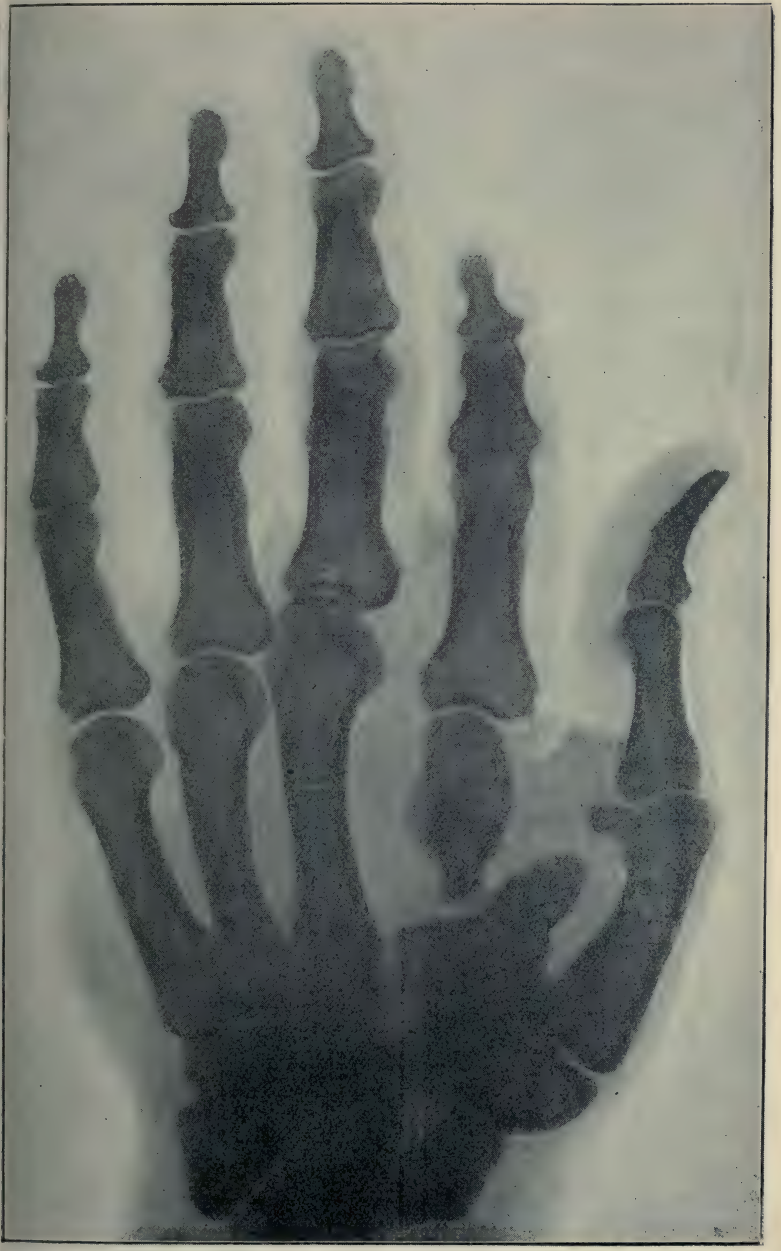

FIG. 61.—HAND SHOWING OLD-STANDING FRACTURE OF METACARPAL BONE. RESULT OF COGWHEEL ACCIDENT.

Somewhat reduced. Dr. J. R. Philpot's case.

height. It will be wise to try and secure a record of impacted intracapsular fracture of the hip, because of its frequent after-shortening, which may be attributed by patients to unskilful treatment. Under such circumstances a differential photograph, showing an alteration in form or relation of the injured side, might be of the utmost value to the medical attendant.

Coxa Vara.—Mr. Lynn Thomas has communicated the case of a young man aged about eighteen who injured his hip in playing football. From an examination of his signs and symptoms, some months after the original injury, he would have concluded that absorption was taking place of the head of the bone, most likely after impaction into it of the neck. An examination by the *x*-rays, however, showed the bending of the neck of the femur to be one of coxa vara. It is waste of time to try and radiograph the hip in adults if one does not possess a 'hard tube.'

In extracapsular fracture of the hip the rays may show conclusively whether the neck of the bone is impacted or not in the great trochanter, especially when a comparison is made with a photograph of the sound side. The knowledge thus gained, whether negative or positive, could not fail to be helpful to treatment, inasmuch as extension is contra-indicated in the impacted variety. Moreover, it would guide the prognosis as to permanent shortening and stiffness of the joint. Generally speaking, a fracture can be readily enough demonstrated by the Röntgen rays in all parts below the hip.

In fractures of the shaft of the femur the value of the radiograph will lie chiefly in its evidence as to the proper setting and subsequent union of the broken ends.

In fractures of the lower end of the thigh-bone *x*-rays are likely to be more useful. Injuries about the knee are apt to cause rapid swelling in and around the joint, so that a thorough examination by ordinary methods is out of the question. Then it is that a confident appeal may be made to the Röntgen method. Without taking off a splint or dressing, we may expect to ascertain one or more of the following conditions: (*a*) line of fracture, whether oblique, transverse, comminuted, T-shaped; (*b*) implication or otherwise of joint; (*c*) separation of epiphysis.

Fracture of Patella, or Kneecap.—Unless the patient be seen at once after this accident, the parts often become so swollen that it is impossible to diagnose the injury. For the investigation of such a case the Röntgen rays are specially adapted. They will reveal not only complete fractures, but also incomplete, —that is to say, where the starred or fissured fragments are kept in position by the aponeurosis. As regards after-treatment, the surgeon will be able by means of a radiograph to determine whether his methods have brought the patellar fragments into good position. Here, too, the results of wiring can be closely followed.

Some years before the introduction of the Röntgen methods the following case came under the notice of the present writer: A patient injured her knee. The medical man who was called in diagnosed dislocation of the semilunar cartilage. A few months later, the joint being stiff, another surgeon administered chloroform and flexed the limb in order to break down adhesions. After this procedure the knee-cap was found broken. The contention of the second surgeon was that the first examination failed to detect an incomplete fracture, which his subsequent manipulation had rendered complete. Wherever the truth lay in that particular instance, it is clear that the medical man first in attendance would have been in a very different position had it been possible to secure the evidence of a Röntgen photograph. Recently at a society two photographs were exhibited of a patella, the day before and the day after its fracture. The facts of the case did not transpire generally, but it may be stated that the first picture, showing the unbroken bone, was the result of an exposure taken for purposes of diagnosis in a stiff knee. Inter-articular adhesions were clearly demonstrated (by exclusion) to be the cause. Forcible flexion led to the subsequent fracture of the knee-pan. The resemblances and the contrast between these two cases are not a little suggestive and striking.

In fractures of the leg, when either the tibia or the fibula is alone broken, the diagnosis, as every practical surgeon knows, is often extremely difficult. Indeed, if there be much swelling, it is in many instances impossible to determine whether the injury is a fracture or merely a sprain. Any such doubt, however, could be speedily cleared away by the rays. The most conservative of surgeons will hardly deny that the ability to settle such a point must constitute a solid advance in practice.

When both bones of the leg are broken, the diagnosis is usually so clear as to need no confirmation. Nevertheless, the method

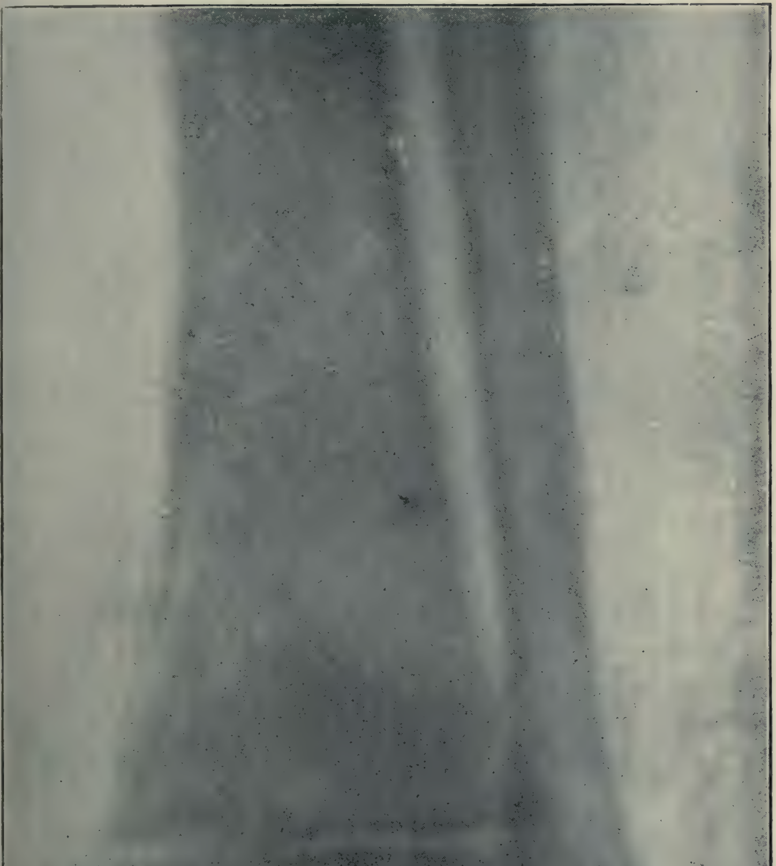

Fig. 62.—Rare Spiral Fracture of Tibia.
Dr. Taft's case.

may be of use in determining whether the degree of obliquity of the fracture or the amount of displacement of the fragments would call for immediate screwing of the bones.

A rare spiral fracture of the tibia was discovered under the rays by Dr. Taft,* and by the kindness of that gentleman is reproduced in Fig. 62. It is instructive to learn that the sensitive plate yielded a clear and unmistakable record of the fracture, which, nevertheless, could not be seen by the aid of Edison's fluoroscope. Dr. Taft accounted for this failure by the difficulty of getting the screen sufficiently near the bone on account of the splints and pads, as well as the swelling of adjacent parts. A second record, taken from the side, showed that the fracture ran up the tibia in a spiral fashion for a further distance about equal to that shown in the figure.

Another unusual fracture of tibia was reported by Mr. Hatch, of Johannesburg.† There were 1½ inches of shortening, together with stiffness and deformity. The Röntgen method showed that the main fracture was transverse below the head of the tibia, with impaction of the lower fragment. The head of the fibula was thrust up, and carried with it the broken-off external tuberosity of the tibia.

By no available means of investigation other than the Röntgen rays could the exact nature of the two foregoing fractures have been ascertained in the living subject. There can be little doubt that, as cases accumulate, many hitherto unsuspected forms and combinations of fractures will be recorded.

The double fracture of the leg shown in Fig. 63 is from a picture kindly placed at the disposal of the writer by Dr. F. H. Low, of West Kensington. The patient was a medical student of about twenty-two or twenty-three years of age. His leg was put up in splints in the ordinary way, and he was kept in bed for nine weeks. A ray photograph of his injured leg, taken three months after the accident, revealed the state of affairs to be seen in the picture. The lower fragments appear to have been thrust upwards between the upper, a condition which the medical attendant supposed to be due to the fact that the patient hd used the limb before the bones were firmly consolidated. In the light of numerous other observations, however, it would appear that such irregular union is the rule rather than the exception. A further point of general interest is that, in spite of the apparent extent of the deformity, careful measurement showed only $\frac{1}{8}$ inch of shortening in the whole limb. No noticeable alteration was caused in the gait, probably because there was some compensatory depression of the pelvis on the injured side.

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* *Boston Medical and Surgical Reporter*, February 25, 1897.

† *St. Mary's Hospital Gazette* for March 1897.

As to fractures of the lower end of the bones of the leg, it seems likely that the pathology of Pott's fracture, like that of Colles' of the radius, will have to be rewritten in view of the fresh facts gleaned from its study by the Röntgen rays. An excellent illustration of such a fracture, with dislocation, is shown in Fig. 64.

Special attention has been given to this point by Destot of Lyons, who has detected by the rays no less than seventeen instances of fracture of the astragalus and metatarsals.*

As a result of his radioscopic investigations of fractures of the astragalus, Destot has recognised two chief varieties—(1) *Fracture with displacement:* (*a*) When the displacement is forwards, the fragment projects under the skin, either in the middle line or on one side. (*b*) When it is backwards, the body of the bone bulges out more or less beneath the Achilles tendon. There is also an intermediate type in which the tibio-peroneal ligament accompanies the posterior fragment, and the foot is slightly dislocated forwards. (2) *Fracture without displacement:* (*a*) Complicated; three varieties—calcanean, malleolar, and scaphoid. (*b*) Simple, either through the neck, the anterior or the posterior extremity.

The Röntgen photograph of dislocation of astragalus, with rotation on its transverse axis, is a good specimen of a not frequent injury, and one difficult to realize its exact condition without the *x*-ray method of investigation (Fig. 65).

Fractures of the Foot.—Tarsal and metatarsal fractures are often obscure, and are no doubt at times treated as sprains. An interesting case of this kind brought under the notice of the writer was that of a young lady whose foot was injured by a fall from a bicycle. Some six weeks later, as the foot was still painful, it was radiographed, with the result that an unsuspected metacarpal fracture was at once revealed.

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* 'Radioscopie et Radiographie Cliniques,' Dr. Régnier. Baillière, Paris, 1899, p. 53.

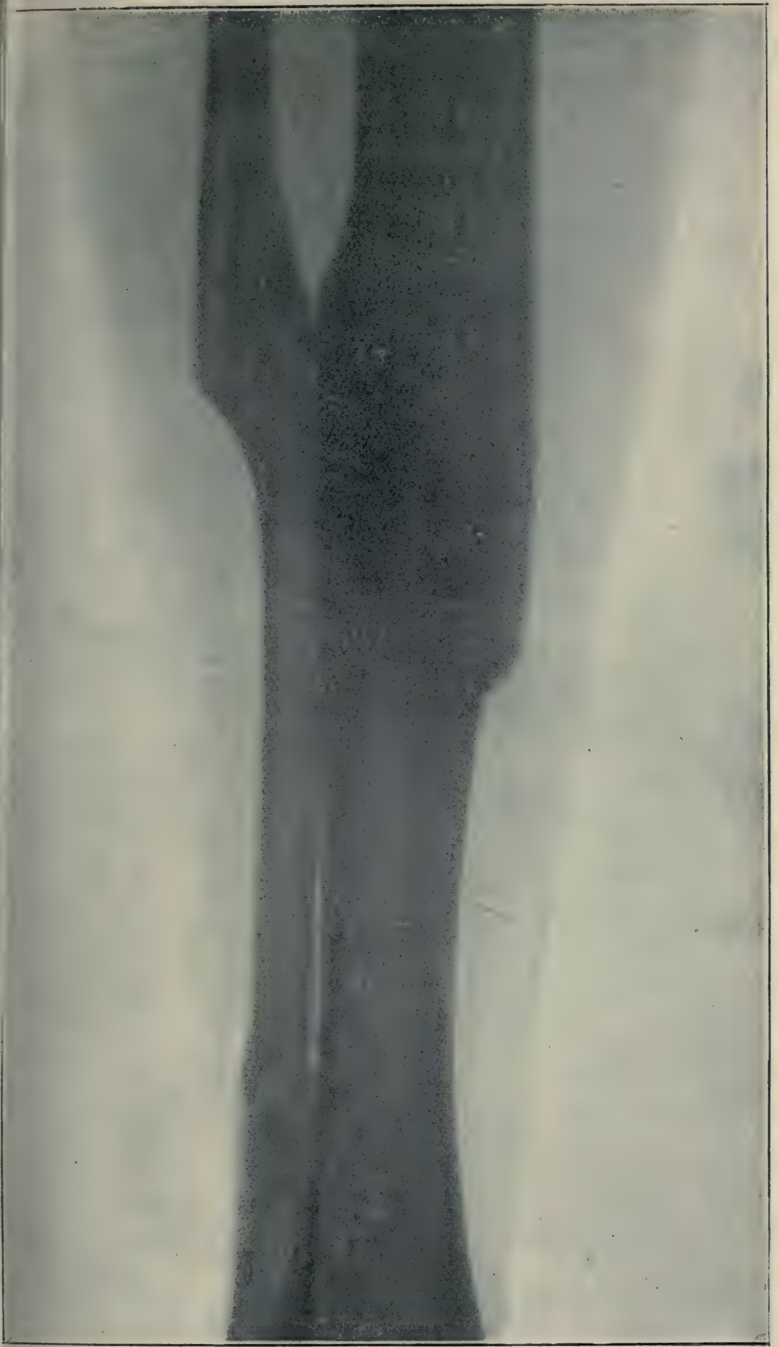

Fig. 63.—Fracture of Tibia and Fibula; Three Months after Injury; no Outward Deformity.

Dr. Low's case.

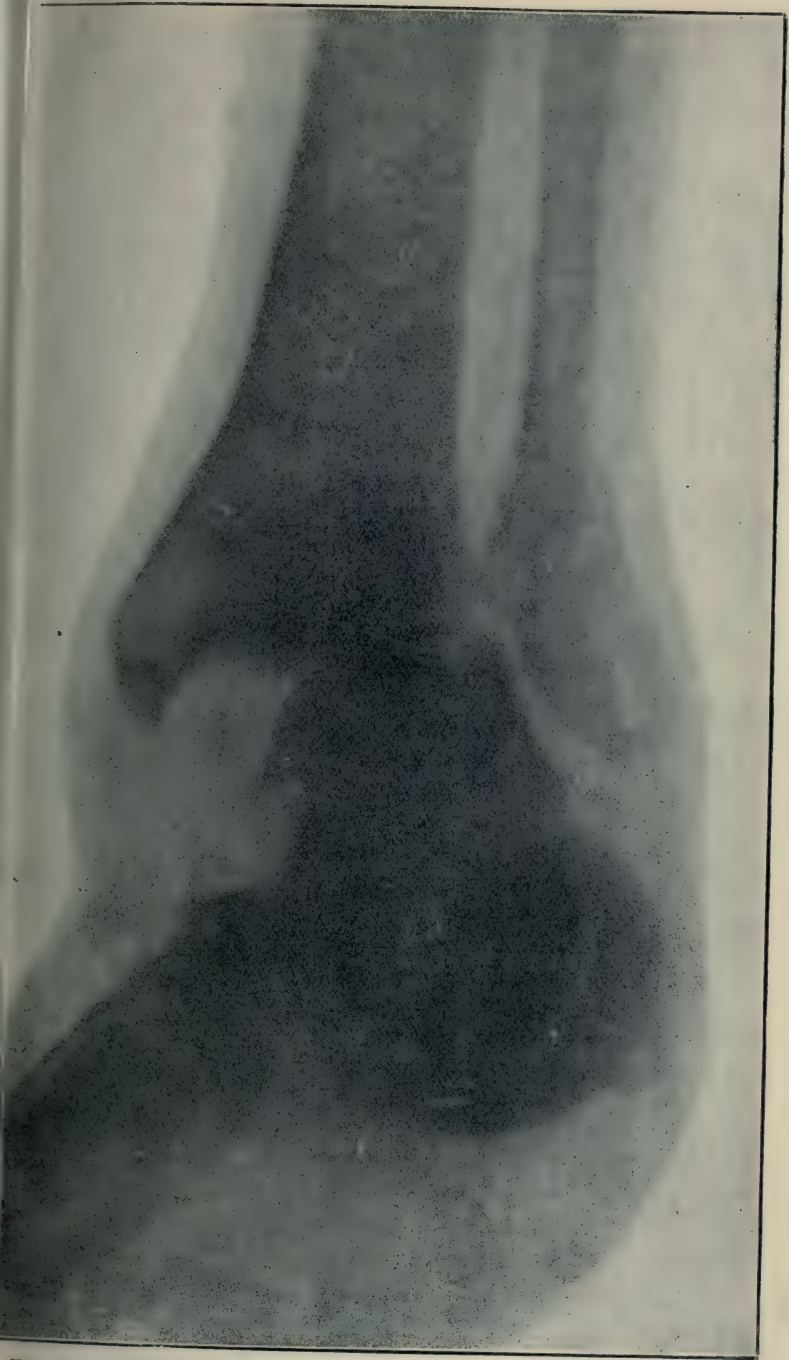

FIG. 64.—FRACTURE OF LOWER END OF FIBULA, WITH DISLOCATION OF ANKLE-JOINT.

Fractures about the Head

Fractured skull may be readily shown by the x-rays when situated upon the face or the cranium—that is to say, anywhere except at the base of the skull. In the lower jaw fractures can be readily demonstrated by using the method described for taking teeth (p. 69). In all doubtful or obscure cases the surgeon will do well to appeal to this method.

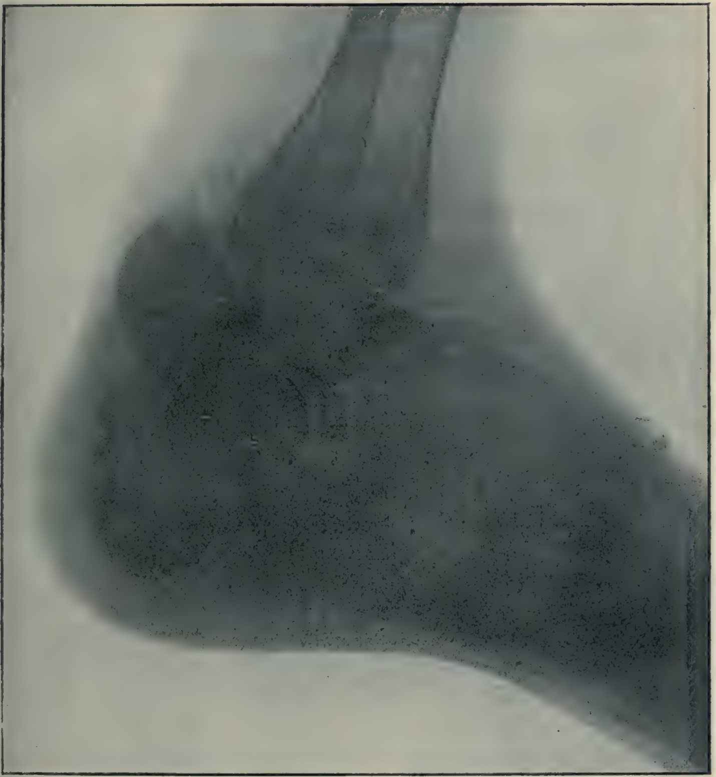

Fig. 65.—Backward Dislocation and Fracture of Body of Astragalus. Lynn Thomas.

Fractures of the vertebræ, from the nature of the case, usually present little difficulty in the way of diagnosis. There are, however, instances on record of unsuspected partial fractures of the vertebræ which have been converted into complete ones by some movement, voluntary or involuntary, on the part of the patient. Thus, a patient has been known suddenly to break off the odontoid process of the axis by nodding his head. Another, again, suffering from obscure cervical injury, has been suspected of malingering, and roughly shaken up, with fatal results. In doubtful injuries of the neck and spine, therefore, it would be advisable, wherever possible, to obtain an *x* ray record. In the neck this is comparatively easy, and no doubt in the process of time equally good results will be obtained lower down the spinal column. Lastly, if fractures of the spine be exactly located by the rays, the feasibility of such surgical methods as 'wiring' might be considered by the surgeon.

An excellent illustrative case of dislocation and probable fracture of cervical vertebræ has been published by Mr. R. J. Pye-Smith, of Sheffield.* The diagnosis was confirmed by Röntgen photographs. It rested on the nature of the accident, the region where pain was experienced, the position of the neck and the nature of the limitation of its movements, and the evidence afforded by the application of Röntgen's rays.

The following extracts will explain the chief points of this probably unique case:

> P. H., a mechanic, aged twenty-six, admitted to hospital February, 1897, complaining of pains in shoulders and upper thorax. On June 20, 1396, he fell from a raised path on to the road 6 feet below, alighting on the right side of the head. He was unconscious for half an hour, and was kept in bed for two days. His neck was stiff and he could not raise his head properly, but in ten days he returned to his work, which involved bending his head over a machine. Six months later pain began in the chest down to the nipples, in both shoulders, and on the inner aspect of both arms.
>
> The head was inclined forwards and slightly to the left, and could not be fully extended either by voluntary or assisted efforts. Nodding movements almost normal. Lateral rotation of head slightly limited to right, more so to left, and accompanied by a soft, grating sensation, as if tendinous fibres were slipping over bony prominences. Lateral flexion of neck markedly diminished, especially to the right. No marked lateral deformity on either side. The spinous processes of the vertebræ above the fourth could not be felt, and seemed to be displaced forwards, the fourth being very prominent. No definite projection, however, of the body of the fourth could be felt in the pharynx. The chest and abdomen moved well in respiration, and neither loss of muscular power nor of sensation was anywhere detected. The pain complained of lay chiefly in the distribution of the descending superficial branches of the cervical plexus of nerves. The Röntgen photograph taken from the side showed the body of the third cervical vertebra to be a considerable fraction of an inch in advance of that of the fourth, whilst the postero-lateral view taken from the left side showed considerable separation of the transverse processes of those two vertebræ.

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* *The Sheffield Quarterly Medical Journal*, October, 1897, p. 30.

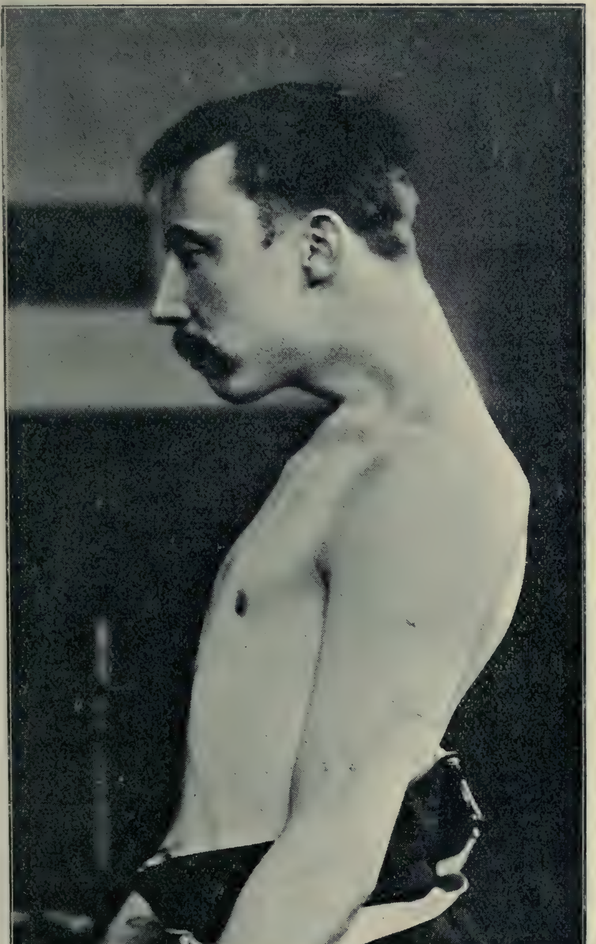

Fig. 66.—Fracture-Dislocation of Cervical Spine.
From the *Sheffield Medical Journal*.

REMARKS.—'The rarity of the long survival of a case of fracture-dislocation of the spine in the cervical region is well known, and depends, of course, on the esion of the cord which so generally accompanies that injury. The rarity of such an injury to bone and ligament without involvement of the cord is perhaps equally great.'

Fractures of the ribs, which are now and then difficult to detect, may be diagnosed by the radiograph. In some instances —as, for example, in lunatic asylums—the proof of such injuries may have a medico-legal interest. Indeed, it may be mentioned in passing that the rays are likely to be of special service to the surgeon when called upon to diagnose injuries of lunatics, mutes, infants, and other folk who are from any reason unable to furnish sound personal evidence of their subjective symptoms. Where death has taken place, a tedious dissection may perhaps be avoided by a Röntgen photograph.

There are special difficulties in the way of securing a proper record of rib injuries. For instance, the movements of the chest wall in respiration will clearly confuse the focus-tube shadow. It has been suggested that the ribs may be fixed by a dressing translucent to the rays, such as silicate of soda. When the fracture is at or within the neck, the movements are sufficiently restrained simply by lying on the back. The present writer, with Mr. Burton, secured an excellent picture in that position of seven broken ribs at the North-Eastern Hospital, London. The patient was a child who had been run over by a vehicle; the fracture had united when the exposure was made, weeks after the accident. The photograph was darker on the affected side, owing to the absorption by the skin of a certain amount of lead from the plaster which had been applied to fix that half of the chest, and also to traumatic pleurisy.

It is also difficult in adults to obtain any record of the ribs over the region of the liver. The writer failed to do so in a medico-legal case where fracture of the lower ribs was alleged to have taken place in the nipple line as a result of direct violence (fall on kerbstone). The patient in that case was an elderly asthmatic man of great girth. In another instance the writer has secured a clear record of ribs over the liver in a middle-aged man of average size, by causing the patient to fix the part to be taken by leaning firmly against the sensitive plate. In young adults and children the ribs can often be beautifully shown through the liver by taking them lying face downwards.

There seems to be no particular reason why lateral fracture should not be photographed if the chest be fixed in some way and the rays directed transversely through the thorax from th sound side.

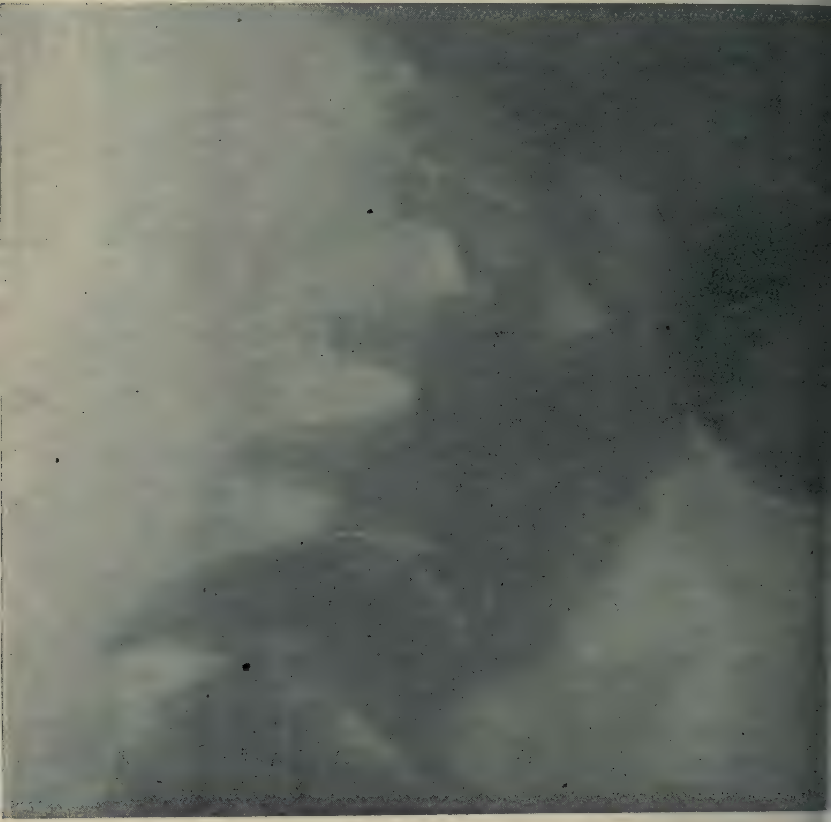

Fig. 67.—Fracture-Dislocation of Cervical Spine. From side. Mr. Pye-Smith's case.

Concluding

This section may be finished by quoting some importa practical conclusions arrived at by two surgeons, one in Germa and the other in America. For some months both made a routi

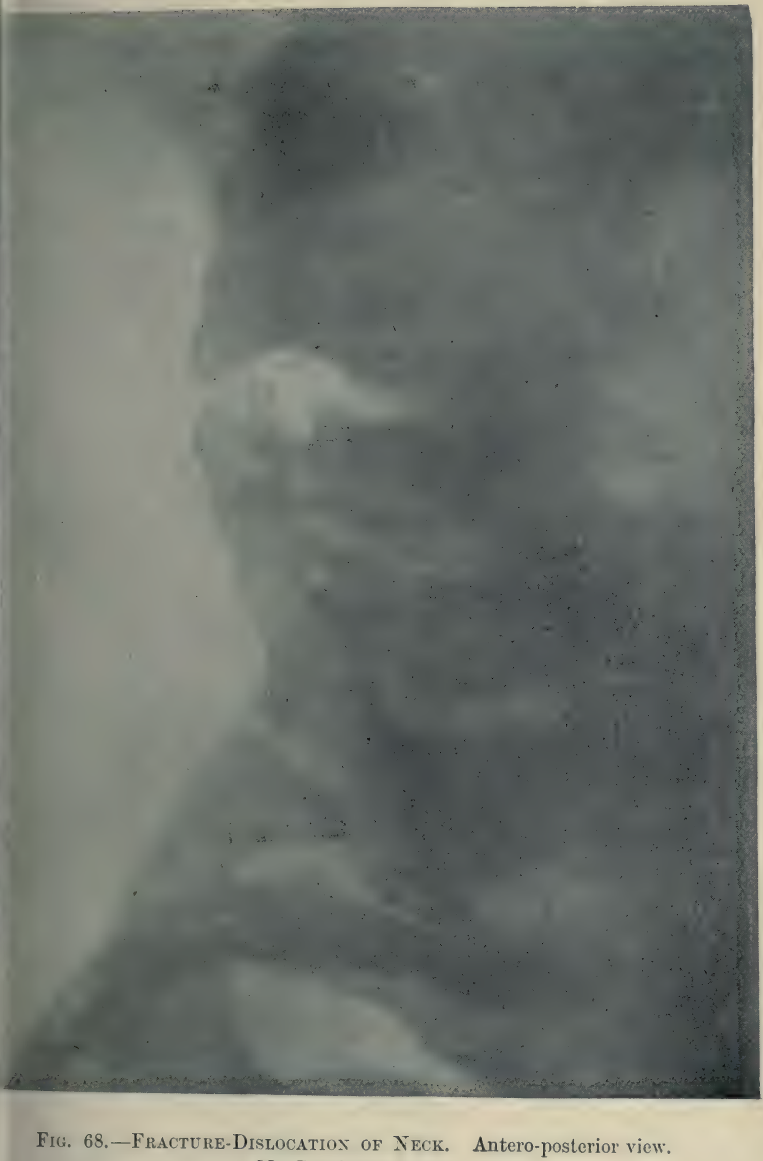

FIG. 68.—FRACTURE-DISLOCATION OF NECK. Antero-posterior view.
Mr. Pye-Smith's case.

ractice of examining with the Röntgen rays every fracture rought under their notice.

The chief point insisted upon by Dr. Richardson of Boston is iat both in recent and in united stages malposition of broken nds is common, although not revealed by any previously known iethod of examination. He mentions a number of cases where ie position was absolutely perfect so far as could be ascertained y ordinary means, but in which, nevertheless, a Röntgen ray hotograph showed considerable displacement.

Oberst of Halle finds that without the aid of anæsthetics and vithout handling the parts he can make an exact diagnosis as o the position, the nature, and the direction of fractures. He hus avoids the danger of laceration of vessels and of other tructures that attends manipulation of the fragments. Ether he iow reserves for painful reductions. He also makes a practice of aking a radiogram at the end of treatment. His main conclusions re as follows :

1. The ideal or perfect union is rare.

2. In all oblique fractures there is more or less overriding of he broken ends.

3. In bones that are deeply seated considerable deformities nay escape notice.

4. In cases followed by long-continued functional disturbances, the Röntgen rays invariably showed overriding of fragments to a greater or less extent, when manual examination revealed no deformity.

Dislocations

In this class of injury the surgeon will usually arrive at an absolute diagnosis by ordinary methods.

A dislocation may be examined with advantage when the parts are too swollen and painful to admit of manipulation. When complicated with fracture, the value of the new method can hardly be overestimated for the ease with which a difficult diagnosis may be reduced to a certainty. To take a concrete instance, let us suppose a dislocation of the elbow to be examined by the x-rays, which may demonstrate one or more of the following fractures as a complication—(1) of the coronoid, (2) of the olecranon, (3) of the neck of the radius, (4) of lower end of humerus, (5) of condyles of humerus, (6) through epiphysis of humerus. The importance of trustworthy evidence on any o these points must be clear, when one considers to what an exten such knowledge must modify diagnosis, prognosis, and treatmen

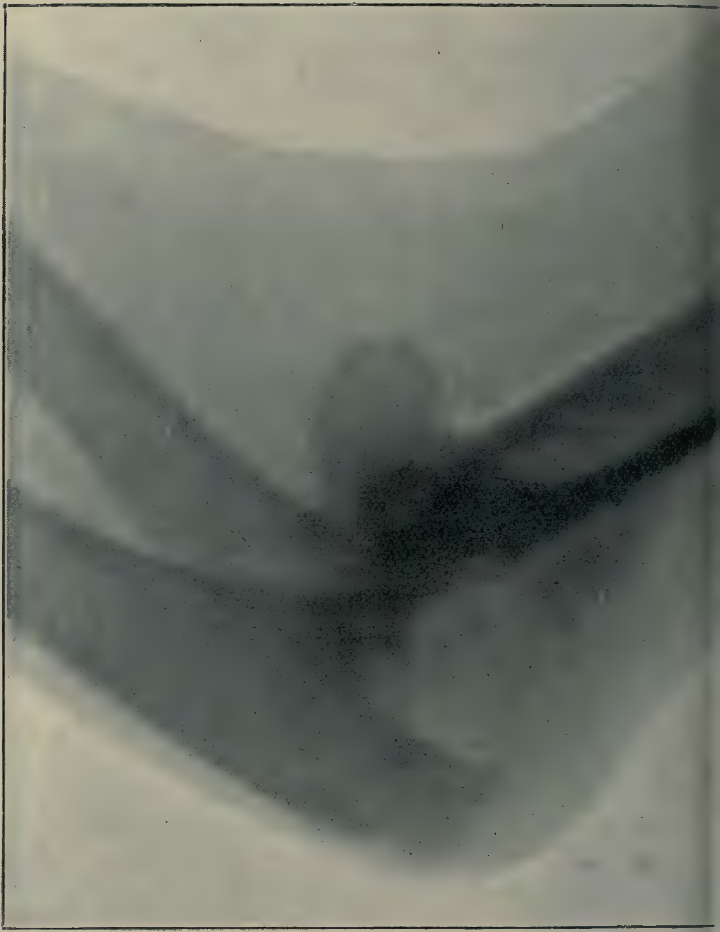

Fig. 69.—Backward Dislocation of Bones of Forearm in a Child.

The illustration of backward elbow dislocation of both bones the forearm in a child shown in Fig. 69 is from a ray photogra taken by Davidson.

The backward dislocation of the first phalanx of the thun

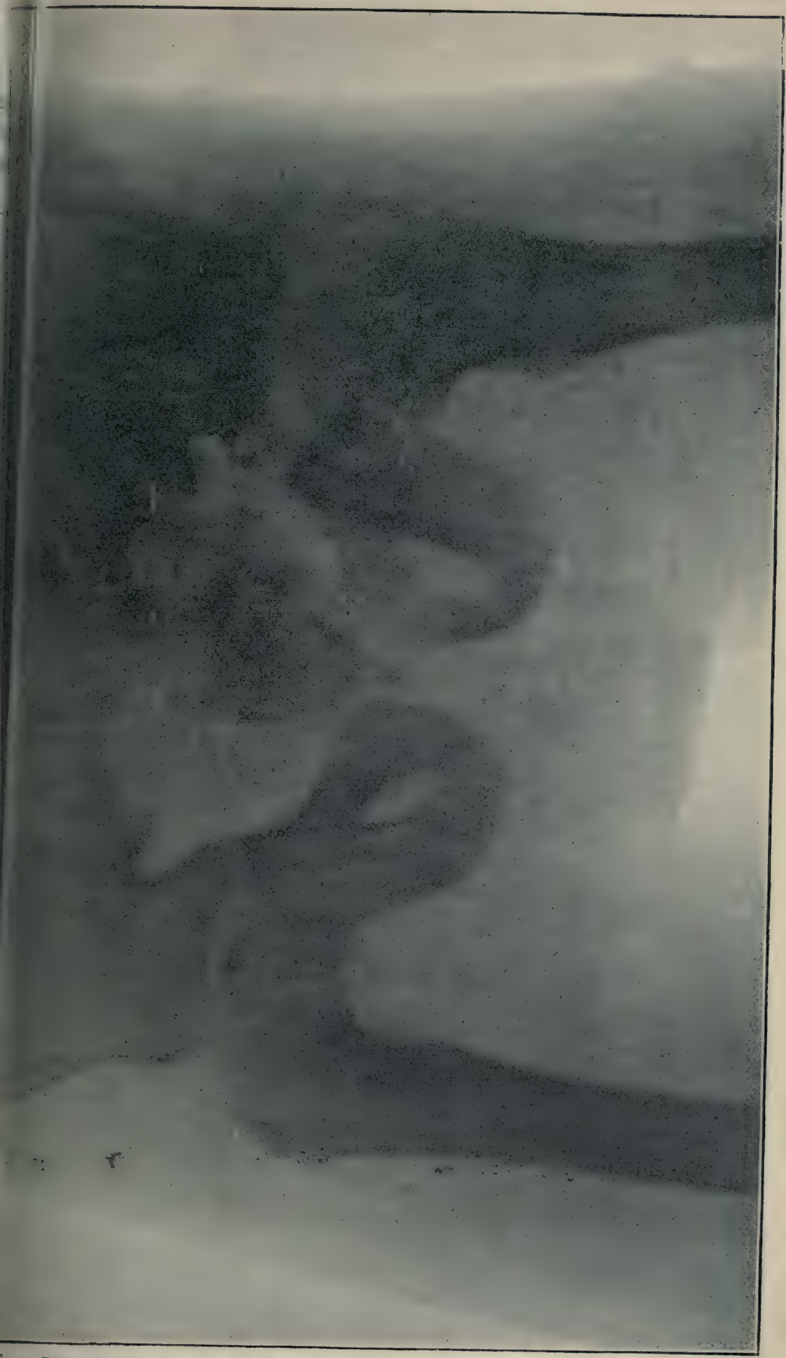

Fig. 70.—Pelvis, showing Rickety Distortion of Neck of Thigh-bones.

upon the metacarpal has always been a matter of surgical interest, chiefly because of the difficulty often experienced in replacing the bones. It is interesting to note that the rays have confirmed the anatomical theory advanced many years ago by the late Sir George Humphrey, that the hindrance was due to the sesamoid bones being carried back with the phalanx, and held there

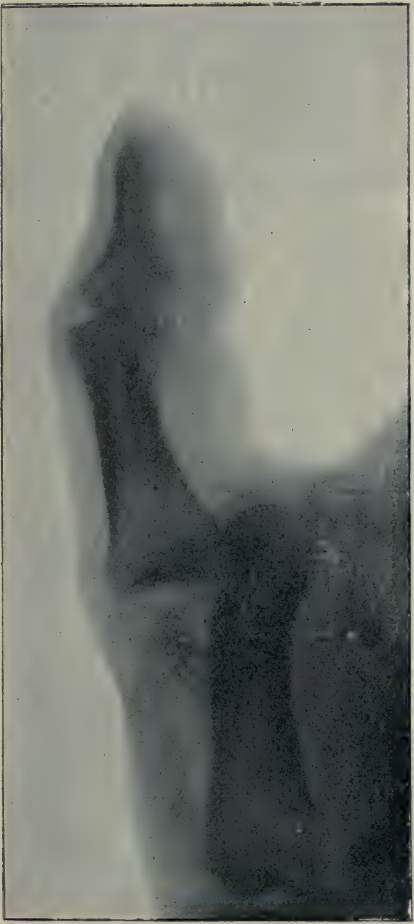

Fig. 71.—Backward Dislocation (old) of Metacarpo-phalangeal Joint of Thumb. Position of sesamoids behind and below head of metacarpal well shown.

Lynn Thomas.

between the separated articular surfaces by the flexor brevis pollicis.

In old-standing dislocations the new photography is likely to be of service. For instance, it will enable the surgeon to ascertain the precise condition of affairs at the seat of injury, so that his subsequent treatment shall be founded upon exact data. Thus, if the rays showed a fresh articulation to have been formed in an old-standing dislocation of the shoulder, the surgeon would not make any attempt at reduction, except under most exceptional circumstances.

Congenital dislocation of the hip can be well shown in children.

The accompanying illustration (Fig. 70) shows a suspected congenital double dislocation to be really a rickety bending of the angles of the thigh-bones.

Dislocation of the body of the astragalus backwards—an extremely rare accident—is shown in Fig. 65. The original radiogram was taken by Mr. Lynn Thomas from a lad of seventeen, who eight months previously, while riding on a moving trolley with his feet in front, struck the roof of an underground cutting.

There is fracture through the neck of the astragalus, while the body is displaced backwards with the trochlear surface in contact with the tendo-Achilles; in other words, there is an axial rotation of 90 degrees backwards through its transverse axis, 'anticlockwise.'

There is no formation of bone in the gap between the neck and the displaced body of the astragalus, for the fibular malleolus is distinctly recognisable. The tibial malleolus is seen resting upon the two segments.

In Stimson's seven cases of this particular injury 'persistent flexion of the terminal phalanx of the great toe was present' (Keen and White's 'Surgery'). A similar condition was well shown in this instance.

A comparison of the bones and tendons of this radiogram with the illustration of a like injury in Treves' 'System of Surgery' (vol. i., p. 1025) is not a little striking.

(c) Injuries to Epiphyses

The importance of injuries to the epiphyses is now recognised by surgeons, and existing knowledge on the subject has been brought together in an exhaustive monograph by Mr. Poland.*

The damage may occur in intra-uterine life, during birth, or in childhood; most often perhaps between the years of eleven and eighteen, up to the union of the last epiphysis, usually at twenty-three, although that may be delayed in some cases until thirty years or more. The Röntgen ray worker will be guided in the reading of results by the following table :*

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* 'Traumatic Separation of the Epiphyses.' By John Poland, F.R.C.S. London: Smith, Elder and Co. 1898.

THE TIMES OF THE UNION OF THE EPIPHYSES TO THE DIAPHYSES OF THE LONG BONES.

At the 16th year	The upper epiphysis of the radius.
Between the 16th and 17th years ...	The olecranon epiphysis of the ulna.
At the 17th year	The lower epiphysis of the humerus.
At the 18th year	The internal epicondyle of the humerus.
Between the 17th and 20th years ...	The epiphyses of phalanges of toes.
Between the 18th and 20th years ...	The epiphyses of phalanges of fingers and lower epiphysis of ulna.
About the 20th year...	The metacarpal epiphyses.
Between the 18th and 22nd years ...	The upper epiphysis of the humerus.
Between the 19th and 23rd years ...	The lower epiphysis of the radius.
Between the 22nd and 25th years ...	The epiphysis of the clavicle.
At the 18th year	The lesser trochanter.
Between the 18th and 19th years ...	The great trochanter.
Between the 19th and 20th years ...	The metatarsal epiphyses.
At the 19th year	The epiphyseal head of the femur.
Between the 18th and 19th years ...	The lower epiphysis of the tibia.
Between the 19th and 21st years ...	The lower epiphysis of the fibula.
Between the 20th and 22nd years ...	The upper epiphysis of the fibula.
Between the 21st and 22nd years ...	The upper epiphysis of the tibia.
Between the 20th and 23rd years ...	The lower epiphysis of the femur.

Separation of epiphyses is much more common in the male sex, as shown by Poland in the three most frequent situations—namely :

Lower Epiphysis of Femur. – Out of 114 cases, the sex is stated in 96—83 males and 13 females ; all the latter below fourteen years of age.

Lower Epiphysis of Radius.—Out of 112, the sex is given in 89 as 79 in males, and 10 in females ; the whole of the latter being at or below fourteen years of age.

Upper Epiphysis of Humerus.—Out of 119, the sex is given in 104. Of these, 85 were males and 19 females (16 being at thirteen years and below, three above).

The practical worker will find the following tables from the same book of constant value for reference. The statistics are compiled from Poland's own cases of separations of epiphyses.†

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* 'Traumatic Separation of the Epiphyses,' p. 47.

† *Op. cit.*, p. 56.

Upper Extremity.

Clavicle	5
Humerus, upper epiphysis	120
,, lower end (before puberty)	75
,, lower epiphysis at and after puberty	6
,, internal epicondyle	61
,, external epicondyle	9
Radius, upper epiphysis	7
,, lower epiphysis	112
Ulna, upper epiphysis	9
,, lower epiphysis	11
Phalanges of fingers	3
Metacarpus	8
Total	426

Lower Extremity.

Femur, epiphysis of head	35
,, great trochanter	14
,, lesser trochanter	1
,, lower epiphysis	125
Tibia, upper epiphysis	24
,, epiphysis of tubercle	10
,, lower epiphysis	46
Fibula, upper epiphysis	3
,, lower epiphysis	5
Phalanges of toes	2
Metatarsus	2
Total	267

The importance of an exact diagnosis in this class of injuries is clear, as severe deformities often result from them. A certain number of so-called congenital deformities are no doubt caused in this way during birth. Hitherto, however, the surgeon has been hampered by the want of exact means of diagnosis and by the lack of precise pathological data. On these points Mr. Poland remarks:

'At the lower end of the humerus, for example, there are but few anatomical specimens in museums to guide the surgeon in making an exact diagnosis of the numerous and complicated

DIAGRAMS OF THE COMMON FORMS OF EPIPHYSEAL SEPARATION.

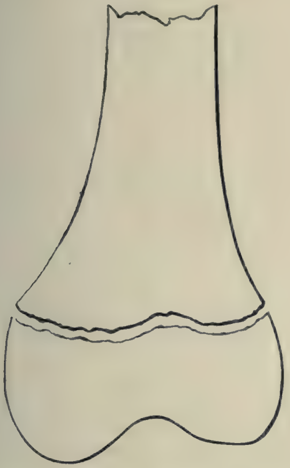

Fig. 72.—Pure and Complete Separation.

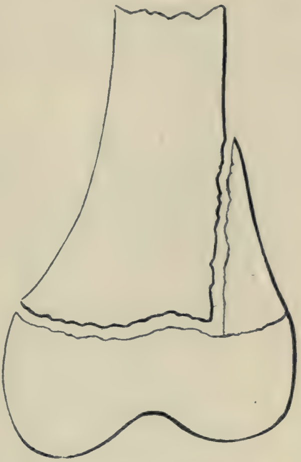

Fig. 73.—Partial Separation, with Fracture of the Diaphysis.

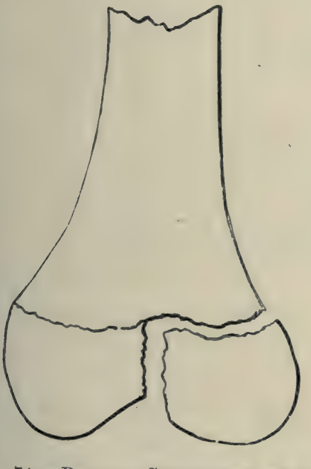

Fig. 74.—Partial Separation, with Fracture of the Epiphysis.

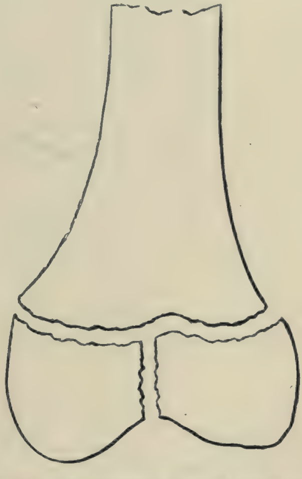

Fig. 75.—Complete Separation, with Fracture of the Epiphysis.

From Poland's 'Traumatic Separation of the Epiphyses,' 1898.

lesions which from daily experience must exist during life. If this knowledge be obtained by Röntgen's method, it will materially assist the surgeon in giving a decision as to immediate operative measures in elbow-joint injuries of children, and in removing some of the many instances of subsequent severe deformity and loss of function of the joint and limb now so little creditable to surgery.'*

The accompanying illustrations, by permission of Mr. Poland, will give some idea of the way in which the forms of epiphyseal injury may be multiplied (Figs. 72-75).

The Röntgen ray worker has now the means of ascertaining the exact condition of parts in traumatism of the epiphyses. He will in most cases want a second or control radiogram of the corresponding sound side, and will do well to make constant reference to the book so often mentioned in the course of this section. Lastly, he will be able to obtain evidence as to the occurrence of plastic inflammatory conditions in epiphysitis, together with such complications as stripping of periosteum, suppuration, necrosis, absorption of bone, and so on.

(*d*) **Congenital and other Bony Deformities**†

The underlying bone conditions of many deformities of the human body can be clearly demonstrated by means of the rays. This fact has been brought out by Mr. Barwell in a series of articles. He remarked that hitherto it had been possible to study such deformities only after death, and upon the dry bone, but that now radiography had made it feasible to ascertain the actual conditions upon the living body, during the continuance of muscular and fascial tension.

It may be laid down as a general law, with regard to such deformities, that the Röntgen rays confer upon the surgeon the power of doing, with pretty accurate precision, what he has hitherto been able to do but tentatively—namely, to plan beforehand the mode and extent of his osseous operation. An excellent example of this general statement will be seen in the accompanying illustration (Fig. 76), reproduced by permission of the *Lancet*.‡

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* 'Traumatic Separation of the Epiphyses,' p. 97.

† This section has been kindly revised by Mr. H. A. Reeves, F.R.C.S.

‡ 'On Various Forms of Talipes as depicted by the *X*-Rays,' *Lancet*, 1896.

Mr. Barwell says of it: 'The reader will perceive that the x-rays have marked out an abnormal length and a downward bend of the neck of the astragalus as being the obstacle to the restoration of proper form to the tarsal arch.' Fig. 77, also from the *Lancet*, gives an excellent illustration of a healthy foot bent strongly downwards.

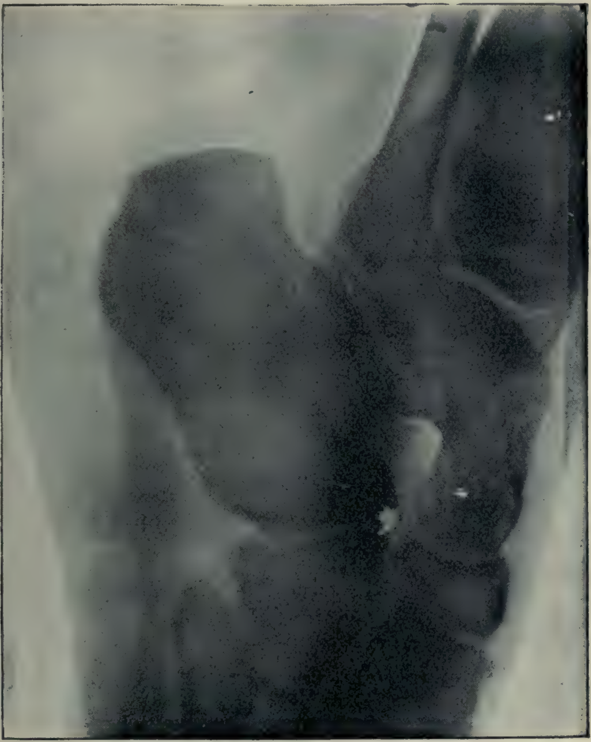


FIG. 76.—TALIPES EQUINUS IN A YOUNG MAN OF NINETEEN: DEFORMITY BEGAN AT THREE YEARS OF AGE.
Rowland.

In deformities of the spine the rays often afford valuable information. This is all the more likely now that operations in that region are becoming matters of everyday surgery. A good instance of the diagnostic value of the rays in cervical cases will be found mentioned under the section 'Diseases of Bone' (p. 163).

Numerous cases of polydactylism and allied congenital deformities have been published. In one or two instances the radiograph has indicated the appropriate line of operation upon supernumerary fingers and toes.

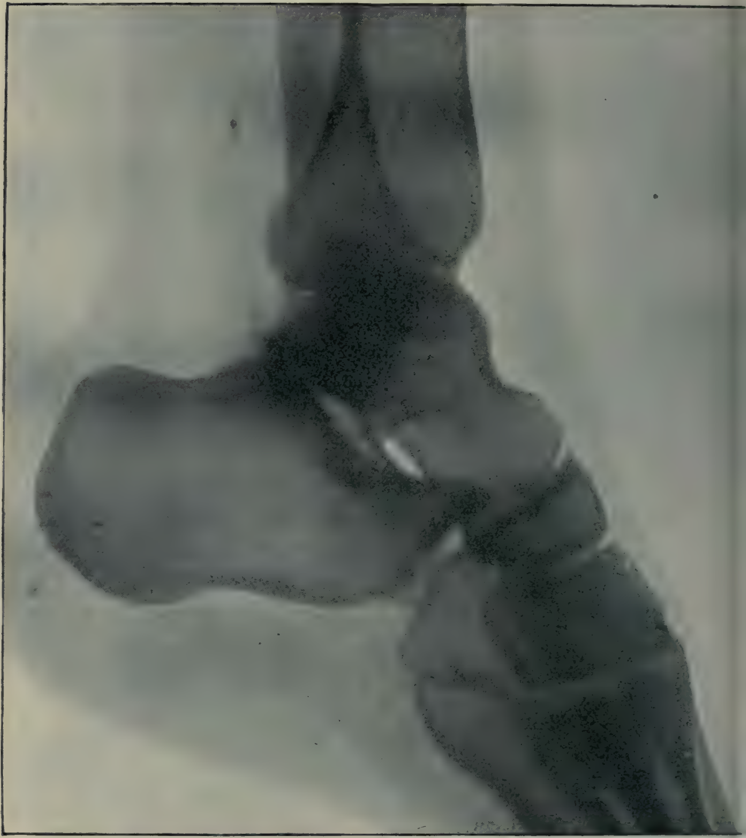
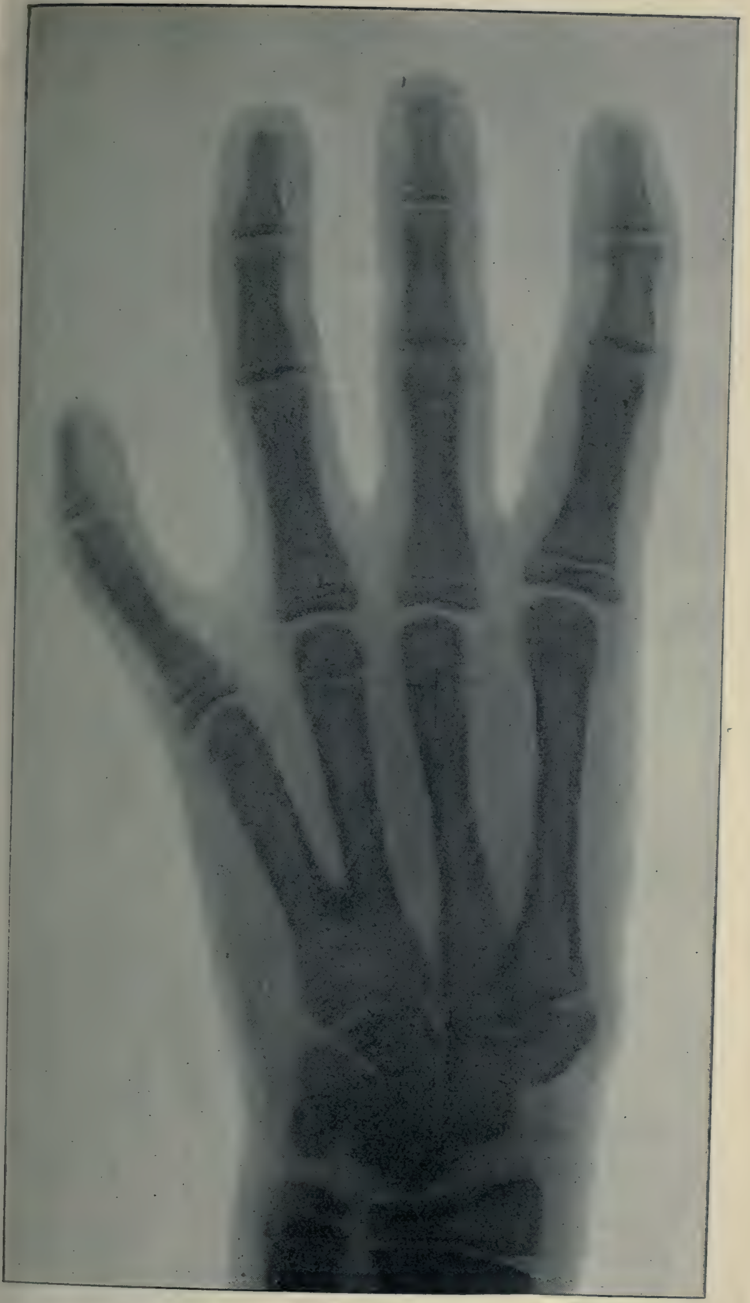


FIG. 77.—A NORMAL FOOT BENT STRONGLY DOWNWARDS.
Compare with preceding figure.

The writer appends an interesting example of polydactylism The case was kindly placed at his disposal by Dr. Milne, the medical officer of Dr. Barnardo's Home in London (Figs. 8 and 82).

The hands and feet in these illustrations are from the sam



Dr. Walsh.

FIG. 78.—MR. REEVES' CASE—THUMBLESS RIGHT HAND OF PATIENT IN FIG. 80.

ubject. The hands appear to be wanting in fingers, but the adiogram shows that it is really a case of polydactylism, with upernumerary thumb. One of the missing fingers, the digit of he right hand, appears to be represented by a rudimentary halanx forced down between the heads of the second and third netacarpal bones.

The feet, however, show suppression of toes, and suggest a wo-toed type. The picture of the right foot is indistinct owing o trembling of that member during the exposure. It is interesting to note that the other foot and the hands were not affected n a similar way, but were perfectly steady—a fact which may possibly point to some nerve instability or other local peculiarity.

The two Figures 78 and 80 are from a girl of twelve under Mr. Reeves at the Royal Orthopædic Hospital. The thumbs are absent in both hands—a rare congenital deficiency. In addition, the left arm, which is rudimentary and much shorter than the other, shows a remarkable condition of bony skeleton. Humerus, radius, and ulna are blended into one long bone, with an outstanding spur at the site of the obliterated elbow-joint. The fifth left metacarpal is partly developed.

Some interesting developmental defects with radiographic pictures were shown at the West London Medico-Chirurgical Society, March 3, 1899.* They included both proximal and distal deficiencies of the limbs. Four principal explanations have been advanced: (1) Interference with arteries; (2) nerve disturbance; (3) intra-uterine amputation; (4) reversion to ancestral type.

Dr. G. T. Beatson has described a congenital deformity of both thumbs in a girl four years of age.† The radiographic picture reproduced in Fig. 79 shows an extra wedge-shaped bone between the first and terminal phalanges of the thumb. Both the end phalanges were bifid. There was a family history of extra digits and toes and broad thumbs and great-toes, and also of webbing. The father's thumbs were not bifid at the end phalanges, but the terminal phalanx of one great-toe was partly bifid, with two distinct nails. Dr. Beatson quotes the statement of Coats that 'deformities of fingers and toes are to a certain extent interchangeable, the one being transmissible from the other.' He also mentions Gegenbauer's definition of the atavistic view, namely, 'the reappearance of a more primitive organization, or a reversion to a primary state.' With regard to his own case, he considers it fair to assume that, looking to the family history of hyperdactyly, the extra bone found in the thumbs of his patient was the rudiment of another finger, and that the bifurcation of the ungua phalanx indicated how the process would have been complete had it gone on to a full termination.

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* *West London Med.-Chir. Journal*, April, 1899.

† *Scottish Med. and Surg. Journal*, December, 1897.

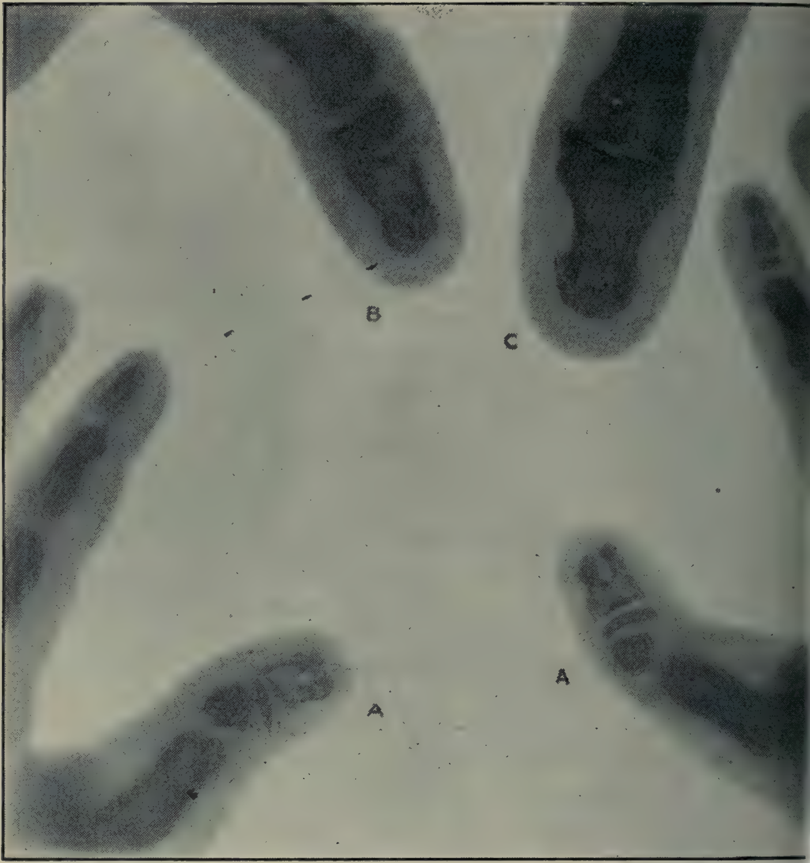
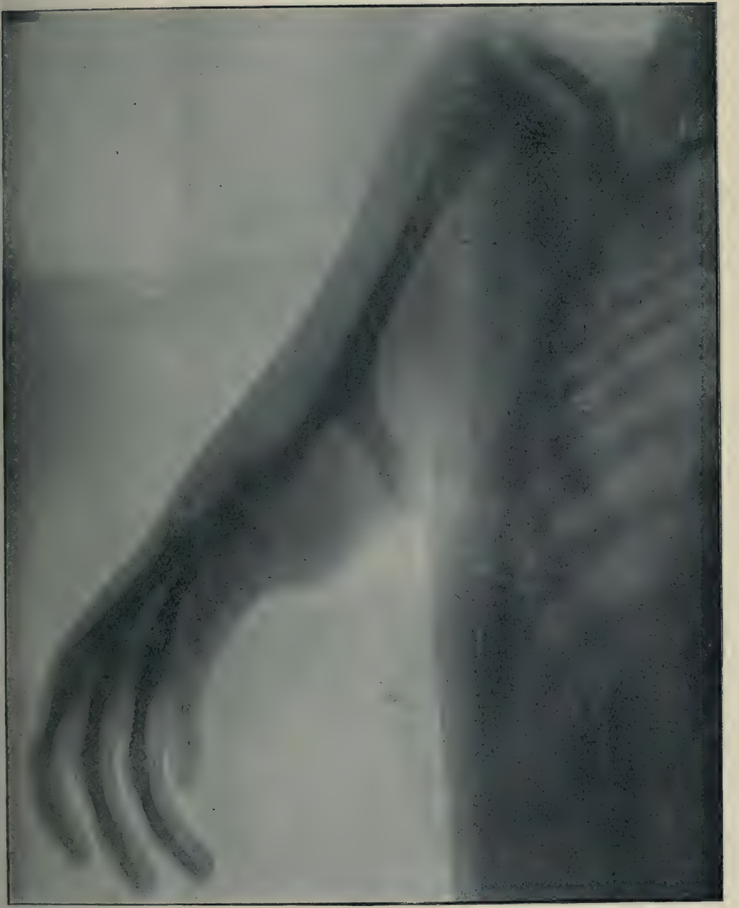


FIG. 79.—DR. BEATSON'S CASE OF BIFID TERMINAL THUMB PHALANGES.

Congenital absence of the clavicle is a rare deformity, ar instance of which was sent to the writer by Dr. George Carpenter



Dr. Walsh.

FIG. 80.—MR. REEVES' CASE OF DEFORMED LEFT UPPER LIMB, SHOWING BONY OUTGROWTH FROM HUMERUS AND DEFICIENCY OF ELBOW-JOINT AND BONES OF FOREARM.

Right hand shown in Fig. 78.

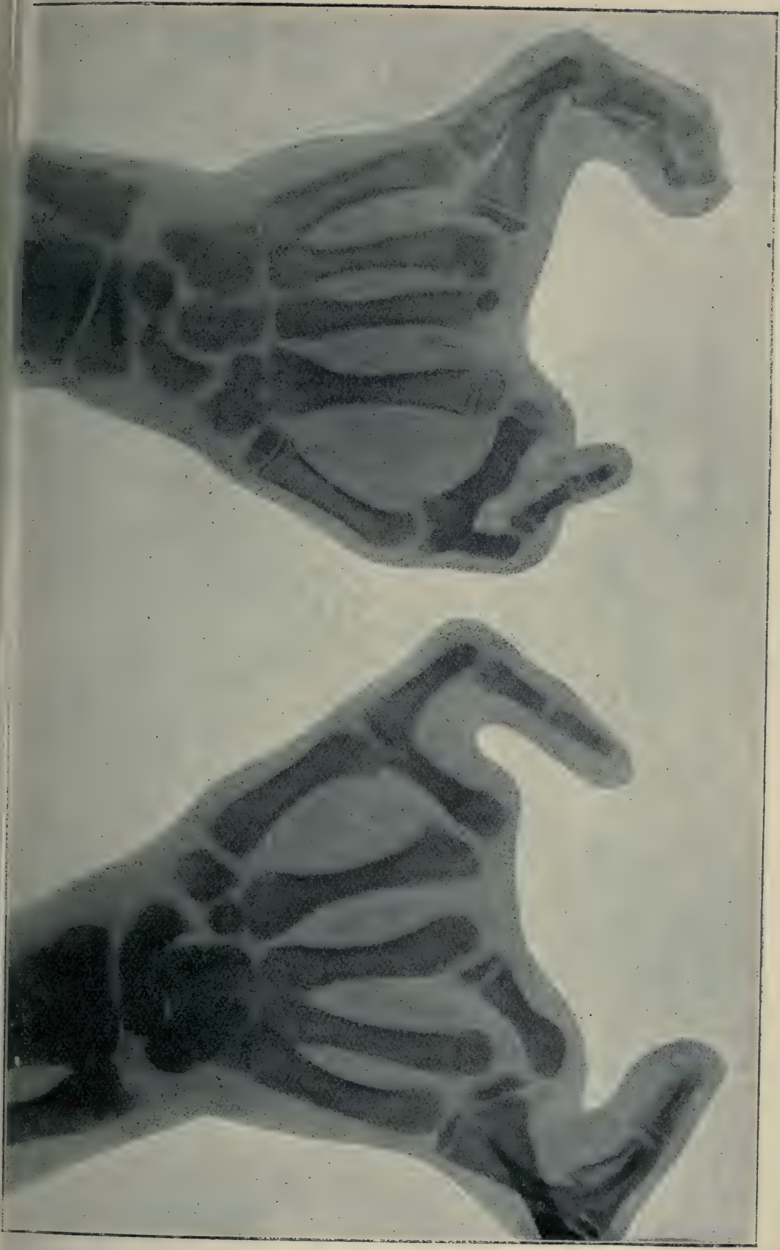


FIG. 81.—POLYDACTYLISM: HANDS OF A GIRL OF TWELVE.
Taken by Mr. Greenhill.

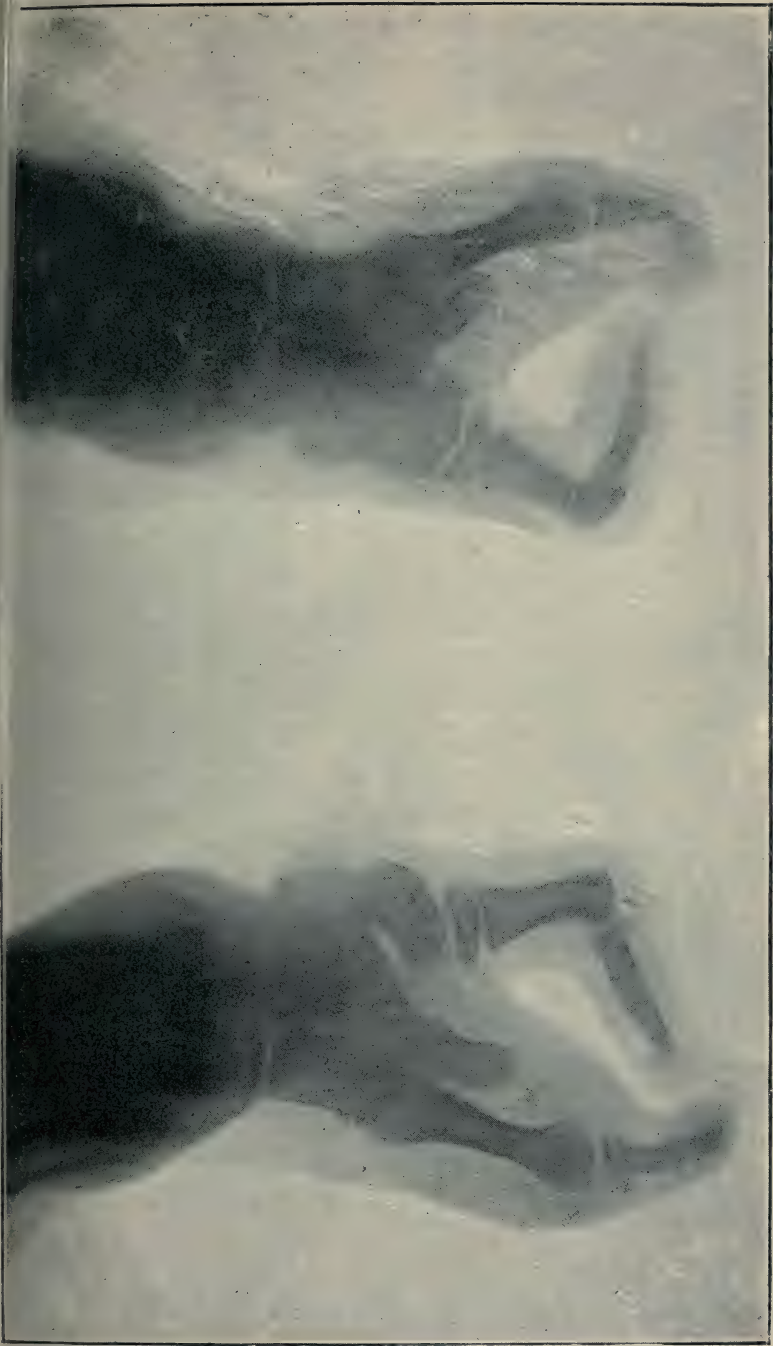
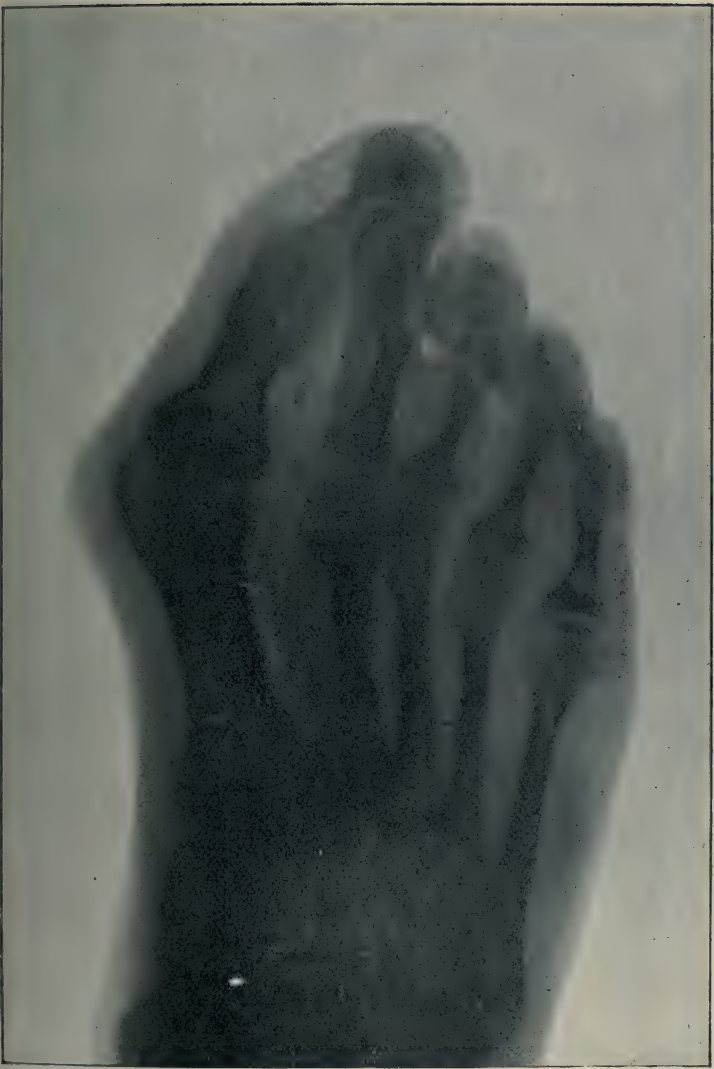


FIG. 82.—FEET OF SAME PATIENT, SHOWING SUPPRESSION OF TOES AND POSSIBLE REVERSION TO TWO-TOED TYPE.

Tremor of one foot during exposure.



Dr. Walsh.

FIG. 83.—HALLUX VALGUS.
Subluxation Outwards of Proximal Phalanx of Great-toe.

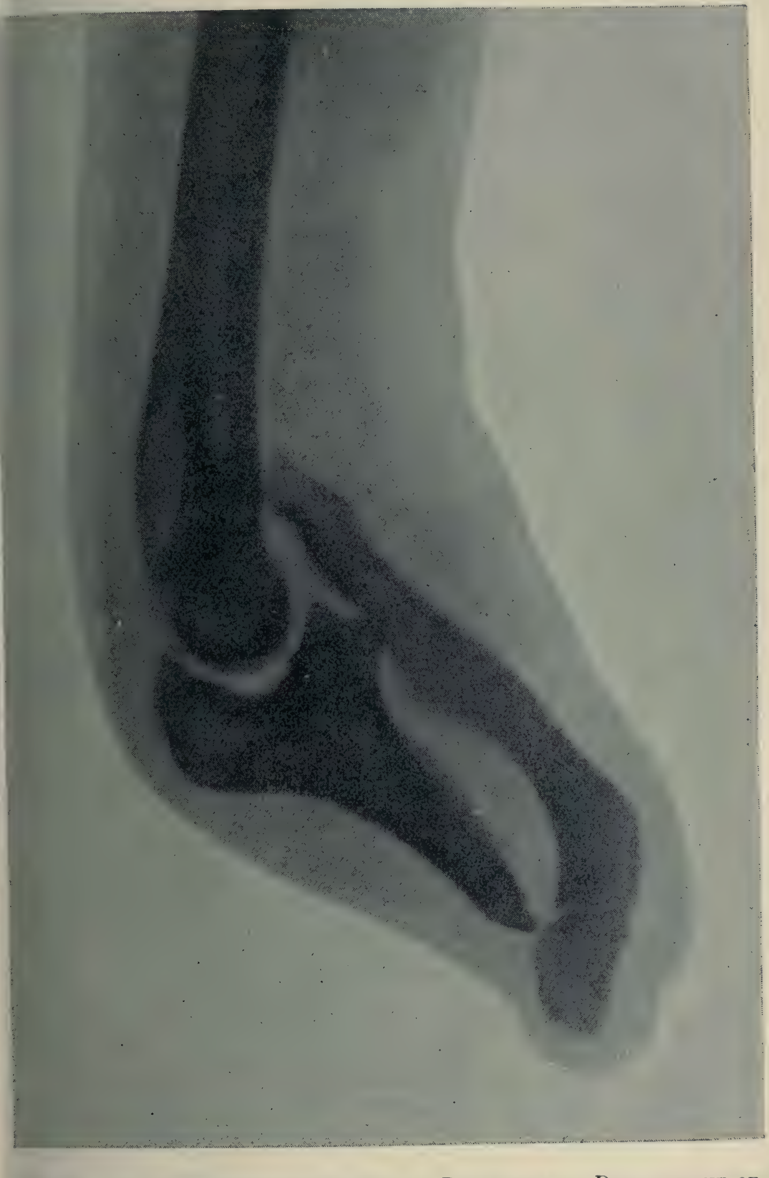


Fig. 84.—Dr. S. D. Clippingdale's Case of Deficiency of Development of Distal Portion of Upper Extremity.

The following is the description of a radiogram taken of the case:*

'The Röntgen photograph of this case was taken with the patient ying on her back, and the focus tube at a distance of 12 inches from the sensitive plate; exposure two and a half minutes. Several abnormalities appear in the photographic record. The first point that strikes one is the apparent absence of clavicles; but on closer inspection the shadow of two fragments can be seen lying in the position of the sternal ends of the collar-bones, that on the left side being longer. These shadows are so faint that it is unlikely they can be reproduced on a process block; their faintness is due to the fact that they are near the focus tube.† No trace of the outer side of the clavicle can be seen on the right side, but on the left there is a faint shadow on the photograph, which, from its size and position, suggests a cartilaginous rudimentary clavicle, with a more or less ossified inner end. The transverse process of the last cervical vertebra is so enlarged as to approach to a cervical rib.'

This patient, a girl of eight, also showed a depression in the upper part of the sternum. She could bring her shoulders together so as to meet in front of the chest. Her family presented the following abnormalities: Father had both clavicles in two pieces, the inner ends of the sternal fragments overriding. A brother, aged fourteen, showed a prominent arch forwards of left clavicle, and division of right clavicle, with inner fragment overriding; his last cervical transverse processes were prominent, especially on the right. Another brother, of nineteen, showed a prominent kink in both clavicles, but no division; his sternum showed a depression the size of half an orange. A sister, aged twelve years, had a divided right clavicle, with overlapping sternal fragment and an enlarged right transverse process of the last cervical vertebra. Another brother, of sixteen, had normal clavicles, but enlarged lower transverse cervical processes. Another sister, of five, was normal. Lastly, a brother of seven had a divided right clavicle, the ends of which were closely united; both the lowest transverse cervical processes were prominent. There was a history of club-feet in two of the family.

Dr. Carpenter gives references to seven published cases. To these may be added one described by Dr. Schorstein,[*] and published with an excellent full-page illustration of the plate taken at the London Hospital.

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* *Vide Lancet*, January 7, 1899.

† Perhaps also to their cartilaginous nature.

Cervical ribs can be readily demonstrated by the rays. A good case was recently described by Mr. Herbert Alderson, M.B.[†] The patient was a young lady twenty-one years of age, who complained of a swelling on the right side of the neck. A Röntgen photograph taken by Dr. F. H. Low showed two cervical ribs, that on the left being rudimentary, and consisting merely of head, neck, and tubercle, articulating with the transverse process of the seventh cervical, but without a shaft. The right rib was more developed, and possessed a shaft that passed downwards beneath the clavicle to the first intercostal space, where it appeared to join the second rib by a cartilaginous union. The shaft was divided by what seemed to be a false joint, which, from the history, might have been the result of a fracture.

Mr. Alderson quotes Professor Gruber, who collected seventy-six cases of cervical ribs in forty-five individuals, recorded between the years 1740 and 1809. To that number he adds a case met with in 1830 by Dymock, and published in the *Edinburgh Medical and Surgical Journal*, vol. xl.; and another in 1896 by Warren, in the *Boston Medical and Surgical Journal.*

To the foregoing may be added two fully-recorded cases by Dr. Danlos and Dr. Bonnarme.[‡] Both were on the left side, the anterior end being free in the one case, and in the other having a subclavicular attachment, which appears not to have been exactly defined, but did not involve the collar-bone.

Anatomically, the vertebra is developed from eight points of ossification, three of which are primary and five secondary; sometimes it possesses an additional or costal centre of ossification. In the seventh cervical this makes its appearance in front of the transverse process, with which it usually unites about the fourth or fifth year. The abnormal development of this costal centre constitutes the cervical rib.

M. Blanchard has classified cervical ribs thus:

1. A complete rib, extending direct from the seventh cervical vertebra to the sternum.

2. A rib with cartilage joining that of the first rib.

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[*] *Lancet*, January 7, 1899.

[†] *British Medical Journal*, December 4, 1898, p. 1638.

[‡] 'Les Rayons *X*,' Paris, Num. 2 and 3, Février, 1898.

3. A rib with two osseous portions joined by fibrous tissue.
4. A rib with free end.

It is likely that cervical ribs are relatively more common than is recognised by anatomists, and that many such cases will be discovered by the Röntgen methods. The diagnosis is of some importance, as the abnormality may simulate aneurism or bony and other tumour, and may give rise to various symptoms by pressure upon nerves or bloodvessels.

Dress deformities may be demonstrated in a striking way by the Röntgen rays, which should place a new weapon in the hands of the advocates of rational dress. Thus, the distortion of the ribs due to the wearing of tight stays lends itself to this kind of illustration. Some time since a series of such radiograms was shown to the Académie de Médecine by Madame Gaches-Sarrante, a Paris physician. The Queen of Portugal is said to have produced some x-ray work in a similar direction. Boot deformities are also readily demonstrated, whether they take the form of dislocated phalanges, bone distortion or damage, bunions, or damage to the tarsal arch. The anatomical relations of an overriding second toe, with the condition of great-toe known as hallux valgus, can be studied in Fig. 83.

The various deformities due to hypertrophy and other changes in the structure of bone, as in rickets, gout, syphilis, Charcot's disease, have been already spoken of. They are all open to Röntgen ray exploration. The deformity of a hand due to rheumatoid arthritis is discussed on page 166.

(*e*) Diseases of Bone

As a bone casts a definite shadow under the Röntgen rays (when not obscured by the mass of surrounding tissues), it follows that bony outgrowths will do the same. In this way one can get a good x-ray record of osseous thickenings and exostoses. An outstanding enchondroma, when it consists of pure cartilage, will throw a faint shadow with a short exposure. As the growth, however, becomes ossified, it gives rise to a denser tracing on the sensitive plate. Subperiosteal thickenings, as in syphilis, may be readily demonstrated by means of the rays, and also the hyperplastic conditions met with in rickets and in Charcot's disease.

A good example of ossifying enchondroma is shown in Fig. 85.

It was taken from a man of about fifty who had sustained an injury to the hand many years previously. On a ray photograph the tumour presented the appearance shown in the figure. From its generally light shade, we may assume it to be composed either of spongy bone or of cartilage that has undergone partial ossification, the areas of the latter being shown by darker mottlings. An interesting point is that the form of the growth is distinctly traceable where it overlies the darker phalanx. This lighter colour may be due to its replacing the compact phalangeal tissue by new spongy bone. A somewhat similar appearance is to be found in Fig. 34, where absorption of the outer shell of the bone has followed the impact of a bullet. As already remarked, the record of spongy bones, such as the sesamoid, is comparatively faint in comparison with that of the medullated bones, an appearance that may be due to the relatively less amount of lime salts present. This difference is well shown in the pelvis, where the sacrum, a light spongy bone, appears faint by contrast with the deep shadows of the solid and compact iliac bones. Another observation that appears to bear upon this point is that of M Potain, who recently reported to the Paris Academy of Sciences the occurrence of light spots on the radiograms of gouty bones.*

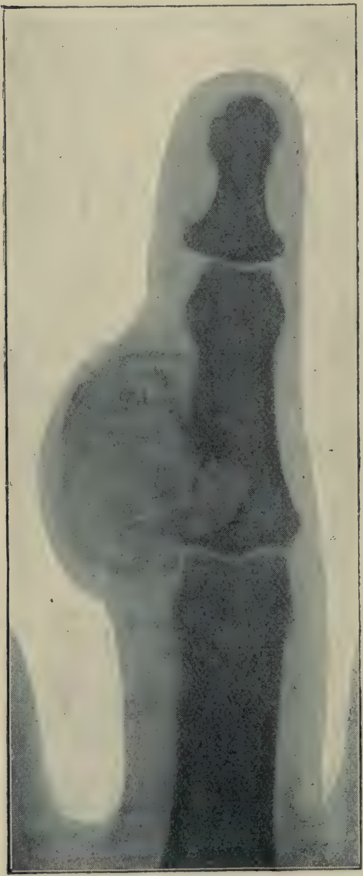

FIG. 85.—OSSIFYING ENCHONDROMA OF FINGER, OF OLD STANDING: FOLLOWING INJURY.

Messrs. Allen and Hanbury.

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* *Medical Press and Circular*, March 10, 1897, p. 249.

Presumably, the compact tissue is more or less altered at the point of projection of these tophi.

This gouty translucency, if such a term may be applied, was explained by M. Potain in the following ingenious and suggestive manner: 'The change appears to be due to the substitution of urates for phosphates of lime. Comparing the different salts which enter into the composition of bone, they are found to be differently permeable to the Röntgen rays. Phosphate and carbonate of lime and chloride of sodium are little permeable, soda and magnesia more so, and urate of lime still more. By making use of two cardboard boxes, the one filled with urate of lime and the other with tribasic phosphate, and submitting them simultaneously to radiography, it is easy to ascertain that the urate of lime is eight times more transparent than the phosphate, because a precisely similar shade is only to be found where the thickness of the latter is eight times less than that of the former.'

In gouty bones, then, M. Potain concluded that the points where urates are substituted for phosphates become more transparent to the Röntgen rays. He further stated that the osseous thickenings due to chronic rheumatism or rheumatoid changes had an increased opacity. If these observations be correct, it follows that it is possible by means of the focus-tube to distinguish whether bony enlargements are the result of gouty or of rheumatoid changes. Assuming that the latter enlargements are more opaque, that condition must be carefully distinguished from the general atrophic state of the bones mentioned when discussing the hand affected with chronic rheumatoid arthritis, shown below in Fig. 86.

M. Potain has made the following practical application of his conclusions: 'In subjects affected with nodosities of Heberden, a lesion of which the gouty nature is still a debated question, very distinct transparent spots are found at the level of the phalanges, which appear to decide the dispute in favour of those who consider gout the primary origin of the affection.'

As regards the outlines of bones, then, the Röntgen rays may be expected to be useful in the hypertrophies due to syphilis, enchondroma, rickets, gout, and rheumatism, and also in the important class of subperiosteal thickenings. Thus, Heller has reported* a case in which a deposit of bone at the margin of a periosteal gumma was clearly shown by a Röntgen ray photograph. A beautiful example of a gumma of the ulna was exhibited at the 1898 meeting of the British Medical Association by Drs. Rainy and Stiles. It showed an irregular* erosion of bone in the centre of the growth, and a fresh formation (sclerosing osteitis) at the edges, and presented a clear picture of the macroscopical changes that were taking place.

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* *Deuts. Med. Woch.*, 1898, xxiv., p. 74.

The opacity of the rheumatoid peri-articular deposit is often well shown in a stiff ankle, while the opposite or general atrophic condition in the same disease is conspicuous in the accompanying radiogram, kindly placed at the disposal of the writer by Dr. J. R. Philpots (Fig. 86).

The subject of the photograph was a lady, aged thirty-one, who had suffered from the disease since the age of thirteen. Her father and mother both suffered from rheumatism, and a sister from osteo-arthritis. Her lower extremities were first affected, but later almost every joint of the body had been invaded, and some permanently stiffened.

On comparing the bones shown in this radiogram with those of a healthy hand, a marked difference will be at once detected. The rheumatoid bones look more fragile; in point of fact, they are atrophied, a condition which renders them more penetrable to the rays. Indeed, from their appearance, it may be pretty safely inferred that they are deficient in bone salts. Their outline is sharper and darker than normal, and their substance lighter Their relatively small size—that is, for a person of that age—i doubtless due to the arrest of development from early disturbe nutrition. Their greater transparency can be best seen in th fifth metacarpal, whereas the darker look of other bones is mos likely owing to the greater amount of tissue to be penetrated o account of the clawed-up hand. It will also be noticed that th bosses of ossified peri-articular cartilage on the phalanges are muc of the same shade as the body of the bone. All the fingers are dis located from the metacarpals. The base of the first phalanx of th fore-finger is apparently fixed against the distal ends of the secon and third metacarpals, but the bases of the middle and thir fingers appear to be partly wedged between the third and fourt and the fourth and fifth metacarpal heads respectively. Th plate shows how a radiograph will afford anatomical data for th

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* *Lancet*, April 15, 1899.

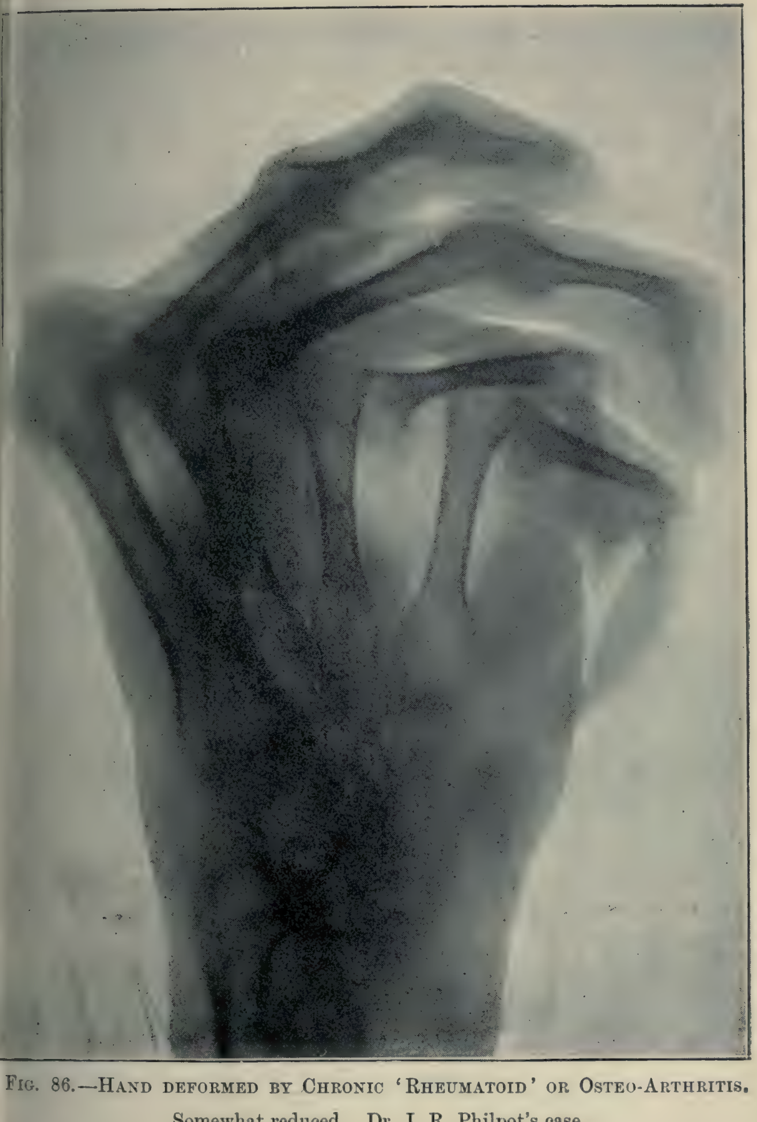

FIG. 86.—HAND DEFORMED BY CHRONIC 'RHEUMATOID' OR OSTEO-ARTHRITIS.

Somewhat reduced. Dr. J. R. Philpot's case.

explanation of such deformities. At the same time, however, it should be borne in mind that the proper reading of the facts of the radiogram is by no means always an easy matter. Lastly, it may be pointed out that the shadow of the thumb confuses the radial half of the figure.

Mr. Espin, of Newcastle, has noted a similar transparency in the bones of tuberculous subjects. In one case—that of a youth of sixteen, with a locked wrist following injury—he found 'the bones of the carpus ill-defined, and the ulna and radius, metacarpal bones and phalanges, abnormally transparent.' The transparency was in marked contrast with the appearance of the bones of the other wrist. His second case was that of a young man whose radius had been previously removed for tubercular disease, and who had also suffered from a tubercular abscess. On examination, he found that all the bones of both arms and legs showed an abnormal transparency.

Transparency, denoting malnutrition or atrophic changes, has been noted by various observers in such maladies as osteo-arthritis, osteomalacia, tubercle, and cancer, and also in the course of senile decay.

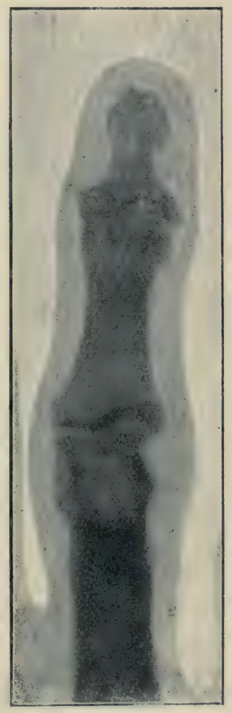

FIG. 87.—FINGER OF CRICKETER, SHOWING ABSORPTION OF BONE AND FIBROUS ADHESIONS OF JOINT.

Another instance of absorption of bone, apparently after abscess, is the following: The patient, a healthy man, about thirty years of age, was struck by a cricket-ball at the end of the right ring-finger, which was painful and swollen for several months, and ultimately became stiff. Except for some awkwardness in writing, he suffered little inconvenience from the resulting deformity. Upon presenting himself at a Metropolitan hospital a radiogram was taken, which clearly showed osseous union at the terminal joint of the affected finger, while the base of the second phalanx was hollowed out, apparently as the result of an abscess. From the view here given (Fig. 87) it can be inferred that any union between the radial half of the joint surfaces is certainly fibrous, while that on the ulnar side is probably of the same nature.

The bony changes that take place in the various pulmonary and non-pulmonary osteo-arthropathies can be well demonstrated. A good Röntgen photograph of the hypertrophic non-pulmonary form of that condition was shown at the Edinburgh British Medical Association meeting by Dr. Steven, of Glasgow. The differing texture of the new and the original bone was well demonstrated in the record of the fresh osseous formation round the shafts of the radius and the metacarpal bones.

In subperiosteal thickenings the differing density of the new and the old bone is readily revealed by Röntgen methods. This contrast is especially conspicuous in cases where necrosis of the shaft is surrounded by an irritative hyperplasia of periosteal bone.

Hæmophilic Bone Conditions

The joint changes met with in hæmophilia can be studied conveniently by means of the rays. These enlargements are not infrequently diagnosed as cases of tubercular arthritis until the diagnosis is cleared up by aspiration. In one instance* a leg was amputated under the impression that the knee was affected with quiescent tubercular arthritis, and the patient, a boy of ten, died twenty-four hours later from uncontrollable hæmorrhage. Dr. Shaw gives an account of a case in the *Bristol Medico-Chirurgical Journal* (September, 1897). He describes enlargement of elbows and knees, which were attacked with acute recurrent peri-articular effusions, preceded by sensory phenomena. The afflicted joints were found on examination to be in a condition similar to that of osteo-arthritis, but, unlike that disease, it does not attack the fingers and toes. The articular ends of the bones were much enlarged, the cartilages extensively absorbed, with well-marked 'lipping' (osteoplasia) at the edges of the articular surfaces. An accompanying Röntgen photograph showed great enlargement of the head of the radius, some lipping at the edge of the sigmoid fossa of the ulna, and thinning of the articular cartilages. Other papers referred to are by Greig Smith (*Bristol Medico-Chirurgical Journal,* 1884, ii. 264) and Bowlby (*St. Bartholomew's Hospital Reports*, 1890, xxvi. 77).

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* *Medical Record*, 1896, xlix. 336.

At the conversazione of the Röntgen Society in November, 1898, the author showed an x-ray photograph of two knees, one of which was subject to recurrent hæmophilic attacks. The case was sent by Dr. George Carpenter. The affected joint was hazy and indistinct in contrast to the sharp definition of the sound knee. A similar haziness is met with in other chronic periarticular affections, as in osteo-arthritis and tubercular synovitis, also in inflamed pleura and rheumatic muscles.

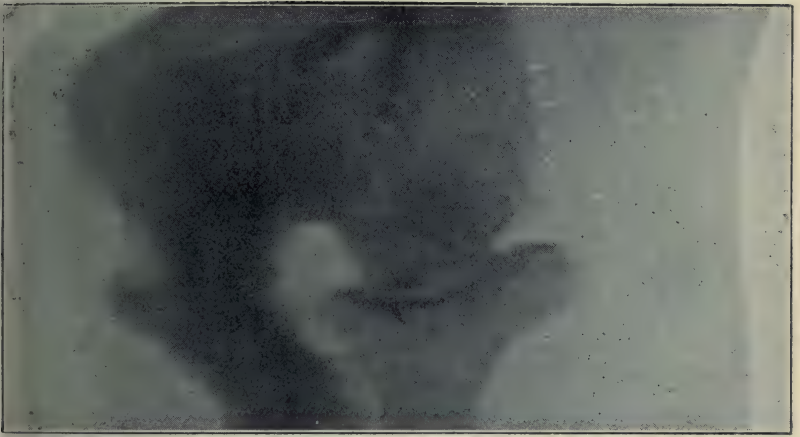

Fig. 88.—Knee in Hæmophilia.
Dr. Shaw's case.

Caries of Bone

Mr. Noble Smith* published an interesting case in which disease of the cervical spine was revealed by the radiograph. Various diagnoses had been made of the patient's condition, as, for example, hysteria. The Röntgen photograph, however, disclosed an irregular mass of bone replacing the upper four vertebræ of the neck. This evidence proved the existence of a severe lesion that had undergone extensive repair. Not only did it clear up the diagnosis of an obscure case, but it also yielded important indications for future treatment.

In another case recorded by the same surgeon, a provisional diagnosis of caries of the cervical vertebræ had been suggested by the presence of torticollis and other signs and symptoms. However, the radiograph showed conclusively that the spine was not affected. This negative result warranted alternative positive conclusions as to the nature of the malady.

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* *British Medical Journal*, 1896.

In some instances osteo-myelitis may be demonstrated by the rays. However, as pointed out by Geissler, the rarefactive change is in the majority of cases obscured by the shadow of the overlying necrotic layer.

The bone changes of osteo-arthritis were well illustrated by a case reported to the Paris Académie des Sciences by Professor Lannelongue.* A patient at the Hôpital Trousseau had been affected for several years with an osteo-arthritis of the knee-joint, which was anchylosed in an extended position. The diagnosis was fully confirmed by a radiogram, which showed hypertrophy of the lower end of the femur, together with atrophy of the upper epiphysis of the tibia. Between the two bones a light interval proved the absence of a bony union.

Fig. 89 shows a case kindly furnished by Mr. Lynn Thomas. The conditions of the knee-joint probably resulted from a former tubercular synovitis. There is extensive erosion of the tubercular surface of the femoral epiphysis, while the diaphysis is apparently healthy.

In a stiff joint, bony anchylosis usually shows under the rays as a continuity of osseous structure that is unmistakable. On the other hand, fibrous union, as we have seen, is inferred from the negative evidence of a light interval between the articular surfaces. Dr. Joachimsthal, of Berlin,† mentions a case in which a boy of sixteen had the knee excised. The site of the operation was examined by the Röntgen method eighteen years later, when the bones of the leg and thigh were seen to be welded together into one solid bone, bent at an obtuse angle. The compact tissue at the edges and the bars of the cancellous tissue both showed a perfect continuity. This adaptation afforded a good example of the change of structure and form that may follow altered function.

New growths in the substance of bone may at times be photographed by the Röntgen rays. The first case of the kind was recorded by König, who found a bright spot, with dark contour,

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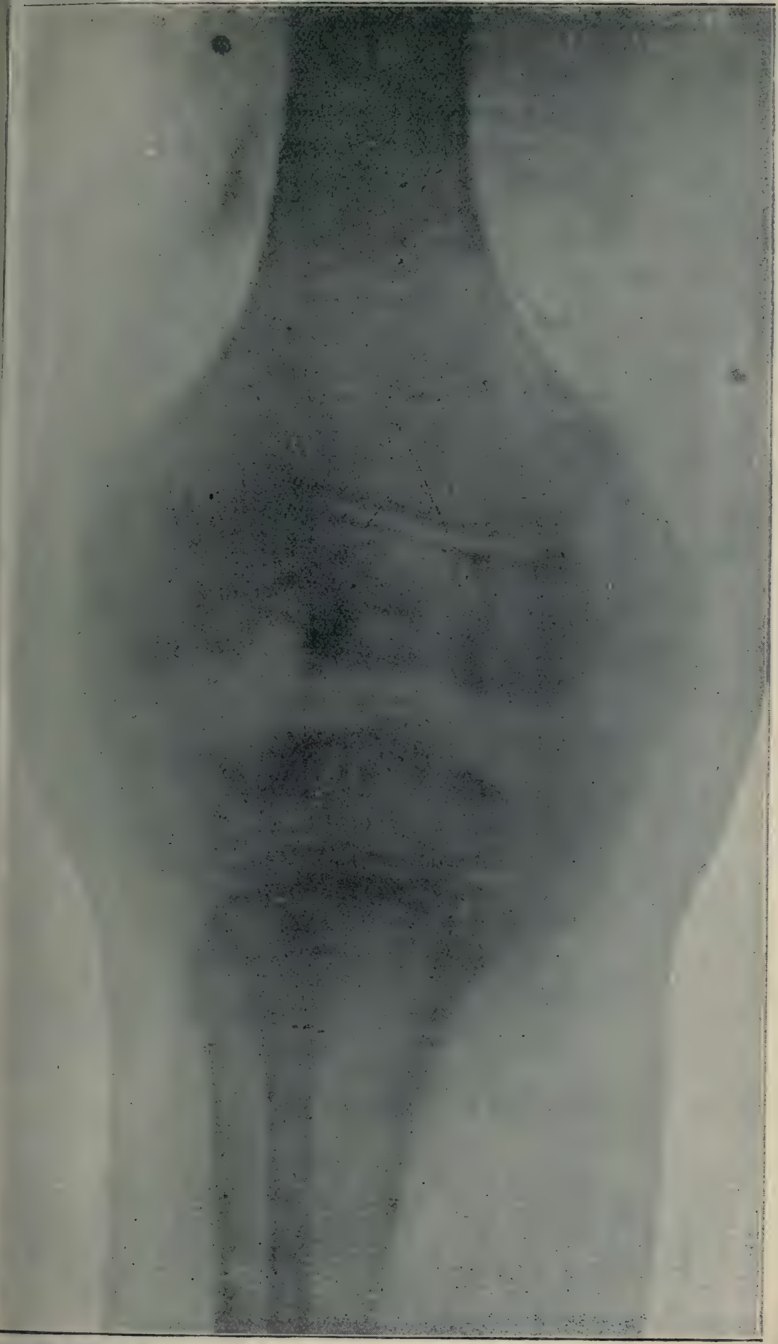
* Paris Thèse, No. 53, D. 23, Louis Laurent.

† *Therapeutische Monats.*, February, 1897.



IG. 89.—KNEE-JOINT SHOWING EROSION OF CARTILAGE OF FEMORAL EPIPHYSIS. SHAFT OF FEMUR HEALTHY.

Lynn Thomas.

the size of a shilling, in the upper part of the tibia to be due to sarcoma. Since that time many sarcomata of bone, central and otherwise, have been reported, some of them accompanied with fracture.

Dr. Richardson of Philadelphia says that by the aid of the fluoroscope he has been able to watch the growth of an osteo-sarcoma of the radius from day to day. His case is thus described:

'General W——, aged fifty-nine, had suffered for twelve months from a painful swelling of the right wrist. By means of the fluoroscope, the ulna was seen to be intact, the radius to terminate abruptly in the faint shadow of a carpal tumour. A thin shell of the radius could be seen remaining. The diagnosis of osteo-sarcoma of the radius, made from the history of the case and from inspection and digital examination, was practically proved by the fluoroscope and the skiagram. A previous consultant had assured this patient that the tumour was an aneurism of the radial artery. In a second skiagram, taken a month later, the shell of bone had entirely disappeared—a fact that demonstrated the bony origin of the tumour and the rapidity of its extension. The arm was amputated, and the disease proved to be an osteo-sarcoma of the radius.'*

Dr. Richardson of Boston has reported a case in which exploration of a tumour in the upper jaw of a woman of fifty-one revealed a sequestrum. Subsequent operation brought to light further extensive necrosis.

Bones in Leprosy and Syphilis

As an illustration of the unexpected way in which the *x*-rays come to the aid of science may be taken the researches of Dr. Ashmead, of New York.† For a long time there has been a dispute whether certain bone changes observed in Peruvian mummies were due to a pre-Columbian leprosy, the existence of which he denied. In the absence of radiographic evidence of absorption of the bones of the hand and falling in of the nasal bones, and of other bone changes connected with leprosy, he has confirmed the view already arrived at from other directions that there was no pre-Columbian leprosy in America. The conclusions of this most learned investigation, however, appear to point to the existence of pre-Columbian syphilis.

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* *New York Medical News*, December 19, 1896.

† *The Canadian Journal of Medicine and Surgery*, vol. v., No. 3, March, 1899.

(*f*) Other Surgical Points

To ascertain Results of Osteoplastic Operation

An interesting case is recorded by Howard Lillienthal in which both the desirability and the results of a bone plastic operation were plainly indicated by the rays. His patient had lost the use of a leg after a severe injury. A radiograph showed considerable loss of substance of the body of the tibia. To remedy this state of things, the operation of tibio-fibular osteoplasty was performed by cutting through the fibula, and bending it over to lie obliquely in the long axis of the gap in the shin-bone. The successful result was proved some time afterwards by a Röntgen ray photograph, which revealed bony filling of the gap and restoration of the line of the fibula, with union of the two bones by an osseous bridge.

An important point is that when a piece of rabbit or other bone has been transplanted, the surgeon can ascertain whether it has or has not become established in its new position.

Ossifications of various kinds can be detected. Examples are those occasionally met with in muscle, as the adductors of a rider or the deltoids of a soldier, known respectively as 'rider's bone' and the 'drill-bone.' Another instance is the ossified insertion of the rectus femoris muscle in Charcot's disease.

A remarkable case of progressive myositis ossificans was reported in the *Lancet** by Dr. R. Crawfurd and Mr. Harry Lockwood. By means of radiograms, a tendency to overgrowth of normal prominences and processes was noted—a point of importance, as the new bony growths in the muscle are always in relation to the abnormal enlargements of protuberances. Microdactyly of the thumb was shown to be due to synostosis of the first and second phalanges. Another deformity, described as hallux valgus, present in both great toes, was really caused by synostosis of the metacarpal bone and the first phalanx. The latter deformity has been noted so often in relation with the disease, that the authors regard it as part and parcel of the malady.

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* *Lancet*, April 15, 1899.

Ossifications of the costal cartilages are shown in old persons. One remarkable instance of premature ossification of the kind in a woman of twenty has been reported as disclosed by the rays.

Calcification of arteries has been shown in the neck and limbs. Atheromatous changes have also been frequently noted in the heart and larger deep bloodvessels.

The subperiosteal enlargements met with after injury in strumous subjects are well shown by the Röntgen rays. In one such case of 'strumous dactylitis' a boy of fourteen suffered from a swollen finger after a fall some weeks previously. A photograph taken by the writer revealed a considerable periosteal enlargement of the first phalanx of the third finger. The effused material, however, was not opaque as a whole, but showed a few granules, apparently of commencing calcification or ossification. The lower epiphysis appeared to be partly obliterated, probably owing to the tilting up of the inter-epiphyseal cartilage by the swelling of the finger, whereby the direct passage of the rays was prevented.

(*g*) Action of the Rays upon Micro-organisms

The Röntgen rays do not appear to exercise any injurious effect upon micro-organisms. Numerous experiments have been made. Thus, Professor W. W. Keen, of Philadelphia, reports* of pink streptococcus, anthrax, *Micrococcus prodigiosus*, *Micrococcus cereus flavus*, *Sarcina aurantiaca*, yellow sarcina, tubercle bacilli, that after exposures, first of half an hour, and then twice for fifteen minutes, neither lethal nor inhibitory effects were exerted upon the cultures. These experiments confirmed conclusions previously published by Dr. Davis in the same journal.

Berton† exposed bouillon cultures of the diphtheria bacillus to the rays for periods of sixteen, thirty-two, and sixty-four hours, but in no instance did he note any injury to the vitality of the organisms.

J. Brunton Blakie, M.B.,‡ as the result of numerous experiments carried out at the University of Edinburgh, concluded that the Röntgen rays have no visible influence on the growth of cultures of the tubercle bacillus, and that the delicate chemical structure of diphtheria toxine, like the delicate chemical structure of the retina, is not affected by their vibrations. Similar conclusions were arrived at by Dr. Francis Pott with regard to the tubercle bacillus, which were unaffected by exposures of eleven hours' duration.

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* *The American Journal of Medical Sciences*, March, 1896.

† *Bull. Gén. de Thérap.*, November 8, 1896.

‡ *The Scottish Medical and Surgical Journal*, May, 1897.

Different investigators have arrived at conflicting results. Thus, Dr. Rieder,* has reported an inhibitive bactericidal action of the x-rays upon cultures of diphtheria and tubercle bacilli, pyogenic cocci, and so on, with an exposure of one to three hours. He used various media on culture-plates beneath a sheet of lead with a round hole cut in it, and so arranged that the rays of a focus tube fell on one portion of the culture. Ordinary light was excluded by covering the aperture in the lead with black paper. He found that the various organisms flourished upon that part of the plate sheltered from the rays by the opaque leaden screen, while on the exposed part beneath the circular aperture they were either absent or feebly developed. From the fact that the gelatin was not liquefied, he thinks that heat was not the inhibitive agent; the chemical nature of the medium was not altered, as shown by the fact that cultures subsequently grew thereon; and ordinary light had been excluded by the black paper. His experiments are suggestive, and point to the possibility of inhibition of bacterial growth by the focus tube rays that are able to penetrate black paper, or to electrical influences.

Boromo† concluded that the rays are negative as regards chromogenic bacilli; that they quicken the sporulation of *B. subtilis*, and retard that of *B. anthracis.* At the fourth Congress for the Study of Tuberculosis, held in Paris in the autumn of 1898, the general opinion was that the rays possessed neither inhibitive nor destructive action upon micro-organisms.

Drs. Norris Wolfenden and Forbes Ross made a series of experiments with *Bacillus prodigiosus.* They found that up to the fifth generation the result of exposure of a culture for one hour to the x-rays was to increase the pigment-forming power, and to induce an exuberant growth.

That electricity exerts a strong modifying and germicidal action upon micro-organisms is well known, and that fact may possibly constitute the fallacy of experiment which accounts for the contradictory results reported by different observers. On the whole, the balance of probability appears to be that the x-rays produce no positive effect upon micro-organisms, and that apparent exceptions may be due to influences that have not been excluded by individual experiments.

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* *Münch. Med. Woch.*, 1898, No. 4, p. 101.

† *Bollett. della Soc. Lanc. degli Osp. di Roma*, xvii., par. i., p. 287.

III. MAPPING OF SKIN SURFACES

* In the course of certain experiments with the Röntgen rays the writer found that it was possible to obtain a record of the coarser fissures of the skin surface. The primary object of investigation was to note the results of radiographing *in situ* the commoner pigments and drugs applied to the skin. It was found that oxide of bismuth, powdered freely over the back of a finger, gave a good tracing of the creases over the knuckles. Following up this clue, a fairly perfect record was obtained of the skin surface, as shown in the plate at the beginning of this book. The best results were secured by kneading putty into the skin, then working up the surface with glycerine, and finally gently and smoothly rubbing with subnitrate of bismuth.

As to the practical value of such a skin map there is little to be said at present. That a record can be obtained in this way of every local peculiarity seems to be undoubtedly proved by the plate ; over the phalanx of the thumb a small convoluted cicatrix of the surface markings could be clearly seen in the original by means of a lens. Such a permanent record might be of value in the identification of criminals, after the fashion invented by M. Bertillon, of Paris. It seems more than likely, however, that a similar end may be obtained by far simpler means. A reference to the frontispiece of this book will show that the addition of the surface markings gives a striking perspective effect that is wanting to the ordinary radiogram. The lines are evidently due to the heaping up in the furrows of a substance opaque to the rays. Under the stereoscope the radiograms of a hand prepared in this way yield a most striking effect.

The surgeon does not always find it easy to cut down upon a needle, or other small object, even when it has been precisely localized by a Röntgen ray examination. In those parts of the body where well-marked skin furrows are found, it would be easy enough to reproduce them in the manner indicated. In that way a complete surface map, with lines of longitude and latitude, would be available as a guide to the knife of the operator.

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* From the *British Medical Journal*, March 27, 1897.

B. DENTAL SURGERY

Now and then great practical help may be derived from the Röntgen rays in dental surgery. The teeth offer greater resistance than bone, and hence throw a distinct shadow when embedded in the less dense osseous substance. A good idea of the Röntgen ray photographs obtained from teeth can be gathered from the teeth shown in Fig. 90, taken from a private collection. They illustrate various pathological conditions, and may be briefly described, taken in series from above downwards, and in lines from left to right:

1. Upper molar, showing exceptional size of fangs and lateral carious cavity.
2. Upper molar, with carious cavity, nerve canals well shown.
3. Molar with carious cavity.
4. Molar with exostosis of fangs.
5. Upper central incisor: exceptional development of fang. Firmly united to its inner surface is a supernumerary tooth, faintly outlined in the radiogram.
6. Bicuspid: cavity of decay communicating with nerve canal.
7. Upper central incisor: showing sphere of erosion, which is indicated by a faint shadow at the neck of the crown. This curious pathological condition, the cause of which is not exactly known, is in its usual site partly above and partly beneath gum.
8. Upper bicuspid: eccentric distortion of fang. This shape is the result of pressure of neighbouring teeth in process of development. Absorption going on in centre of single fang is indicated by the darker area; that is, the thin plate of tooth substance has offered little resistance to the rays.
9. Upper central incisor: half the fang absorbed; small carious

cavity. This tooth is extremely opaque, shown by its relative white look and absence of dental canal tracing, a condition probably due to its necrosis.

10. Lower molar, with large amalgam stopping reaching nearly to apex of fang; that is to say, the filling is nearly all beneath the level of the gum. The metal shown by dense white patch. Compare this absolute density to the Röntgen rays with that of the preceding tooth.

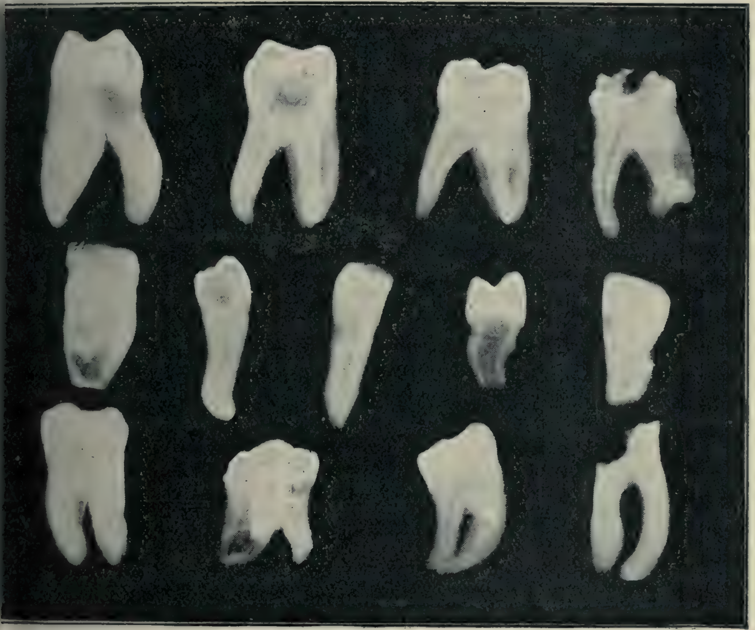

FIG. 90.—SKIAGRAM OF TEETH, SHOWING VARIOUS PATHOLOGICAL CONDITIONS.

11. Permanent upper molar: fangs absorbed by pressure of wisdom tooth, which was impacted between them.

12. Wisdom tooth: fangs sharply hooked.

13. Lower molar, showing convergent fangs and carious crown, rendering extraction difficult.

Mr. Frank Harrison published some of the earlier radiograms of teeth *in situ*. In the *Journal of the British Dental Association* for September, 1896, he has an excellent photograph of a portion of the lower maxilla of a girl of seven. The milk-teeth with their pulp-cavities and fangs are clearly visible, while below the roots of the first and second temporary molars are the permanent first and second bicuspids enclosed in their respective bony crypts. The internal dental structures of the lower jaw were displayed well-nigh as distinctly as would have been done in a dissected specimen.

Mr. Harrison observes: 'The *x*-rays promise to be of great use in dentistry, and will enable the dentist to observe in living tissues what was possible only a short time ago in the dead subject. The genesis of the teeth, the construction of artificial crowns, the anomalies of roots, the difficult eruption of teeth, and many other conditions of organs which are enveloped in tissue opaque under ordinary conditions, become visible by the illuminations of the *x*-rays.'

Dr. Kolle, of New York, has invented an ingenious little instrument for examining the teeth and alveoli, the dentiaskiascope, by which the operator is enabled to inspect teeth and their roots, one by one, with ease and comfort both to himself and to his patient.* It consists of a small fluorescent screen within an aluminium case, so placed that the screen-image is reflected upon a mirror, which the operator views through a tube. For taking photographs the screen is replaced by a protected sensitive film.

A number of interesting cases have been published from variou parts of the world. Thus, Professor Amoedo† figured a lowe jaw in which a wisdom tooth was planted at right angles to it proper axis, with the fangs buried in the ascending ramus. I the same journal M. Saussine‡ described a rare case in whic an upper lateral incisor in a child of twelve lay horizontally i the bone with the fang pointing backwards. By an *x*-ray examination it was ascertained that the fang reached within 2 millimetre of the floor of the nasal fossa, and the appropriate treatment wa indicated.

In one important particular the rays have proved of grea service to the dental surgeon, namely, in the deformities of th jaws due to or connected with non-erupted teeth. In such case he can ascertain with exactitude the position, shape, and size c the teeth within the bone. From the information thus gained he is able both to plan and to perform his surgical operations with exactitude, whereas under previous methods the most skilful man had to act upon probabilities. Lastly, two pathological conditions in which the new method will be now and then invaluable are the tooth-bearing cavity in the substance of the jaw, known as the 'dentigerous cyst,' and abscess of the antrum.

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* 'The *X*-Rays,' by F. S. Kolle, M.D. New York, 1897.

† *Les Rayons X*, 2 Avril, 1898. ‡ *Ibid.*, 5 Mars, 1898.

The method to be pursued in securing an x-ray photograph of the teeth in the living subject has been already described on p. 69.

C. NASAL AND THROAT SURGERY

THERE are several ways in which the specialist in nose and throat diseases may gain useful information from the rays. Foreign bodies may be detected in both cases. In the nasal cavity exostoses and abscesses of the antrum may be demonstrated either by a photograph or according to the method introduced by Dr. J. Macintyre, much on the lines of Kolle's ' dentiaskiascope.'

In describing this method of examining the hard and the soft tissues about the bones of the face, and those of the neck and larynx, Macintyre writes : ' The fluorescent screen is placed inside the mouth, and the lamp outside. Small discs of glass are coated with the salt and covered with aluminium, or, again, tongue-depressors, consisting of flat strips of glass covered and coated in the same way, may be employed. By placing the tube outside I am able to get an image of the septum and other parts of the cavity of the nose on the fluorescent screen in the mouth. In the same way the roots of the teeth may be seen. If the surgeon desire to examine the parts below or above the jaws, he simply puts the Crookes' tube below or above, and passes the rays through the tissues. If he desire to examine the tissues externally—that is to say, to pass the rays through the neck—he places a small fluorescent screen on one side and removes the Crookes' tube to a suitable distance. By this means I have been able to demonstrate the presence of foreign bodies, and need hardly add that they are more easily photographed.'*

Monnier† was able to discover by means of the Röntgen rays the cause of a chronic nasal suppuration, accompanied by epiphora on the same side. The trouble was due to a lacrymal sound that had been broken off, and remained in the lower part of the nasal duct for no less a period than forty-two years. Partial occlusion of the trachea from the pressure of an enlarged thyroid gland has been reported, also cancer of the œsophagus.

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* *Glasgow Hospital Reports*, 1898, p. 306.

† *Archiv. Internat. de Laryngologie*, No. 3, 1898.

The rays have not hitherto achieved much in the ear, but it is likely that abscesses in the mastoid region could be detected. At the Röntgen inaugural meeting in November, 1897, Mr. Griffith Wilkin showed some good ray photographs of detached temporal bones. The present writer has obtained excellent figures of the semicircular canals in infants. It seems likely that the presence of inter-cranial abscess in that region might be ascertained and its exact whereabouts localised for surgical purposes.

D. MEDICINE

IV. REGIONAL

(*a*) Thorax and Abdomen

It is still true that the most striking practical applications of th rays have been made in surgery, but at the same time there ca be little doubt that the future has in store a brilliant field fo Röntgen photography in clinical medicine. In the thorax a grea deal has been achieved by demonstrating changes in outline o the heart and aorta, as well as in the substance of the lungs mediastina, and pleura. As to the abdomen proper, results hav so far not been very encouraging—at any rate, in the adult. I may be confidently hoped, however, that before very long w shall be able to explore all internal regions with fair accuracy.

Good results as to internal organs can be obtained in the case both of small lower animals and of children. In the illustration of the half-grown cat (Fig. 91), the windpipe and it divisions into bronchi bifurcating in the substance of the lun are well and clearly shown. The heart is outlined in front of the chest, and, so far as one can judge, the bones of the sternum are visible through the less opaque cardiac substance. The delicate shoulder-blade is well recorded, and the lower margin of the thoracic cavity sharply defined by the edge of the midriff. In the head, the fangs of some of the teeth can be seen in their bony sockets, especially in the molars of the lower jaw. The cartilages of the nose and the ears are faintly shadowed, and various muscular and tendinous structures can be made out in the neck.

The abdomen of this cat was by no means so clearly mapped out by the rays, but, nevertheless, contained several valuable indications. The main mass of the liver, for instance, was sharply outlined in its upper, but diffuse in its lower margin, while a light space beneath it corresponded with the stomach. The broad light band that curved from the centre of the diaphragm to the lower part of the lumbar spine appeared to represent large intestine. Other convolutions of intestine were clearly shown, especially in the case of a coil of gut that had an extremely light

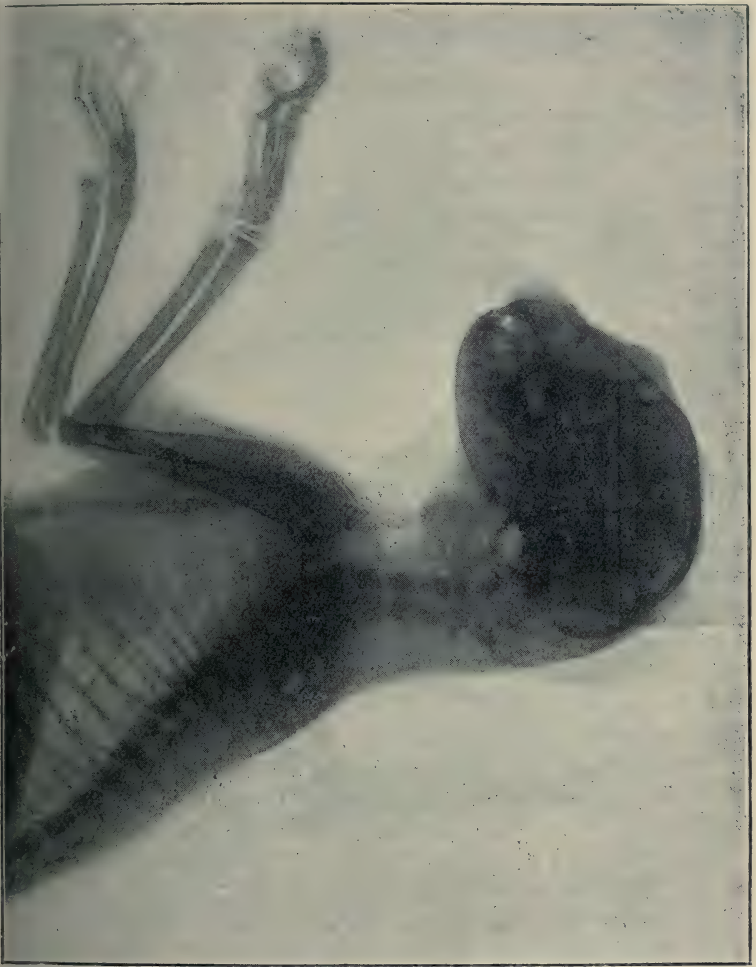

FIG. 91.—HALF-GROWN CAT, SHOWING BRONCHI, LIVER, HEART, ETC. Reduced one-half. By Mr. Cox, Parkstone.

record near the pelvis. This knuckle of intestine had, most likely, been full of gas, and had lain close to the surface of the sensitive plate during exposure.

The tendons, passing from the leg to the os calcis behind, and to the instep in front, were plainly pictured in the original print.

This photograph has been dwelt upon at some length because it gives a good idea of what may be hoped for in the future. It was taken with a powerful coil, giving a spark of over a foot in length. Its clearness of definition was largely owing to the fact that the animal was dead, so that there was no blurring of the shadows by the circulatory or respiratory movements. There seems to be little reason to doubt that what is possible with lower animals will before long be attainable in the case of living adult human beings, so that all deep-seated organs will be brought within the reach of this new method of exact investigation. In other words, the Röntgen rays will some day render to medicine services not less conspicuous than those already conferred upon surgery.

Dr. Macintyre,* who was the pioneer of deep tissue work in this country, has laid down the following rules: (1) A powerful current, 30 to 33 ampères, is necessary, so as to take the photograph instantaneously. (2) The transformer needs a large coil, which will give a 6, 8, or 10 inch spark. (3) It is best to use a small focus tube, which may require prolonged heating. (4) Rapid exposure is absolutely necessary. (5) A mercury interrupter is useful, instead of a spring. He usually places the lamp about 3 feet from the sensitive plate. This distance gives a well-defined shadow, but requires a strong light.

Dr. Campbell Thomson,† Medical Registrar of the Middlesex Hospital, some time ago observed that the fluorescent screen is quicker and better for clinical purposes. By that means it is possible to clear up many difficulties, such as exist in aneurism both of the heart and of the first part of the aorta. He has given several valuable practical hints upon chest radiography. To get a fixed location-point, he suggests a metallic button placed over the nipple, to which it may be secured by a piece of sticking-plaster. In order to secure a record of what is seen in the fluoroscope, he fastens to the back of the fluorescent screen a sheet of white paper, through which the rays would of course pass. He then slides a flat metallic pen or pencil between the chest and the paper, and on the latter he traces the outline as projected in the fluoroscope. It need hardly be added that to carry out this manœuvre the observer would have to continue looking at the screen, so as to ascertain and control the movements of the opaque pen or pencil.

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* *Lancet*, August 22, 1896.

† *Ibid.*, October 10, 1896.

The shadow of the heart is lighter at the pulsating margin. Between it and the liver, upon taking a deep breath, a light interval appears. From the front of the chest the whole of the cardiac outline can be seen; but much less from the back, as the view is obstructed by the spine. From the back a definite shadow with well-marked external border can be seen on the left, and a smaller and less intense shadow, corresponding to the right auricle, on the right of the spine. Outside the body the valves of a heart emptied of blood can usually be well seen. Sometimes the valves, particularly of the right side, can be seen *in situ* in the living subject.

With the fluoroscope on the front of the chest, the position and outline of the heart is materially altered by deep inspiration. The normal state of affairs is thus well described by Dr. F. H. Williams:[*] 'In health the diaphragm lines move as follows: Quiet breathing, ½ inch; full inspiration, 2½ to 3 inches, a little more on the right than the left side. In health the outlines seen on the left of the sternum are as follows: A part of the aorta in some patients may be observed in the first intercostal space; in the second intercostal space a portion of the pulmonary artery; the left border of the ventricle is chiefly seen in full inspiration when the apex and a portion of the lower border are also visible; the maximum pulsation is at the point corresponding to the cavity of the ventricle, about where its outline crosses the fourth rib; during full inspiration the heart moves downwards towards the sternum. To the right of the sternum the outline of the large vessels is seen, and, less distinctly, the right auricle between the second and fourth ribs.'

From the front, then, the heart-shadow fuses on the left with that of the sternum, beyond which the right auricle projects from the third to the fifth ribs; on the right the auricular and ventricular line runs with a bold indented curve from the second to the sixth ribs. This latter line is raised and pushed upwards and outwards by the rising of the diaphragm in expiration. On the other hand, it is elongated and carried downwards and inwards towards the sternum in forced expiration, when a light fine falciform line or a broad band defines the apex and more or less of the lower border. Ordinarily the lower portion of the heart-shadow merges into that of the liver.

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[*] See Paper at Montreal Meeting, British Medical Association, by F. H, Williams, M.D., Boston, U.S.A.; *British Medical Journal*, April 16, 1898, p. 1006.

The shadows, whether seen from the front or the back, can be conveniently recorded on one of the author's clinical diagrams.

If a photograph be taken of the whole heart, it is best taken with the sternum next the tube.

The original of the accompanying radiogram of the thorax was taken early in 1897 from a boy of fourteen, lying on his back. The exposure was twenty minutes, distance of tube from plate 30 inches, spark 6 inches, Apps coil. A similar result would now be obtained in a period of, say, half a minute up to three or four minutes.

It should be borne in mind that fluoroscopy is an art that requires patient study. The education of the eye to recognise objects of varying opacity on the screen can be obtained simply and solely as a matter of practice. A similar observation is to a less extent true of the reading of ray photographs. Nor is it less obvious that the physician who wishes to avail himself of this branch of diagnosis must make himself familiar with the screen appearances of the heart and great vessels, and their relation to the chest walls and midriff, as above described. He must also learn to appreciate the variations of shadow produced by shifting the focus tube or the patient.

(*b*) Heart and Great Vessels: Aneurisms, Enlargements o Heart, and so on.

The fact that the lungs are full of air and easily permeable to the rays makes it possible to get a good outline of the human heart. As the result of a number of experiments on the dead body, Pöch demonstrated to the Vienna Gesellschaft in January 1897, that it was possible in the empty heart to make out the valves and trabeculæ as clear spaces against a darker cardiac background. When the heart, however, was full of water or of blood no such differentiation could be made.

This relative opacity of blood is an important quality so far as concerns the Röntgen diagnosis of alterations in the form of the heart and bloodvessels. The reason why a bloodvessel should resist a long exposure is obscure. We know that after prolonged exposure both biliary and uric acid calculi will cease to cast any shadow, while a rib nearly ceases to do so, and a phosphatic shadow becomes much lighter (Dr. Swain's experiment, p. 119). Mr. C. W. Mansell-Moullin mentioned to the writer a case in which the abdomen was exposed for two hours. The bones left no record, but the abdominal aorta threw a strong shadow.

The future development of internal photography by Röntgen methods will greatly depend on the quickening of processes. The widespread movements of respiration affect more or less the whole contents of thorax and abdomen, while the heart and great vessels, normal and abnormal, are in a state of intermittent activity. Instantaneous photography, were it possible, would enable one to ascertain the exact position of any movable internal part at any fractional time within its periodical range of movement. Thus, some forms of rapidly expansile aneurisms are recognisable on the screen, whereas they cannot be photographed; nor can the latter result be hoped for until the instantaneous photography of the thorax is an accomplished fact.

So far as concerns the respiratory movements of the chest and abdominal walls, the present writer has now and then obtained satisfactory results by causing the patient to fix the part to be photographed by leaning it against a chair or other firm object, upon which the plate was placed. Thus, in taking gall-stones or a tumour in front of the kidney, the patient stood upright and leant against a projecting angle of wall; in examining an asthmatic lung, the patient sat astride a high-backed chair, against which one side of the thorax was pressed.

Dr. Disan* has introduced an ingenious method of recognising alterations in the cardiac outline. First of all he marked on the chest what should be the normal shape of the heart, and mapped out the area thus obtained with a copper wire, which he fastened to the chest with ordinary plaster. He then examined with the fluoroscope in the following way:

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* *Dominion Medical Monthly*, February, 1897.

'At first the greatest strength of current obtainable from the apparatus is turned on. The observer then looks through the fluoroscope, and gets the chief landmarks of the chest—such as the scapula, ribs, spine and convexity of liver—the wire being at the same time in view. The current is then reduced until the heart becomes visible. The fluoroscope is applied to a spot marked at the left of the spine corresponding to the fourth intercostal space in front of the chest.'

In a case, under Dr. Coupland, of doubtful deep aneurism of the chest, the diagnosis was cleared up by the fluoroscope. From the front, slight hypertrophy was noted, and just above the junction of the left cardiac border with the sternum a faint indefinite shadow. From the back, a well-defined shadow was seen on both sides of the spinal column, at about the level of the fourth dorsal vertebra. On the right border this outline was convex and pulsating; the intensity of the shadow on that side was almost the same as that of the heart, while on the left it was lighter and less definite. The evidence thus obtained converted a doubtful into a certain diagnosis.

The pulsating margin of a non-cardiac shadow in the thorax other than fluid, of course, points to aneurism. The observer, however, should remember that bulgings are not uncommonly found in the aorta, and that movements may be communicated to tumours or enlarged glands.

Aneurisms may at times be detected by the rays in the thorax when their presence could not be demonstrated by percussion and auscultation. Several cases of unsuspected thoracic aneurism revealed by the screen have come under the observation of the present writer. In one instance he took a Röntgen photograph of the chest of an elderly asthmatic of heavy build. A good-sized aneurism was seen in the left upper thorax, where, owing to the large and emphysematous lungs, it could not be diagnosed by ordinary physical signs. Indeed, an experienced physician subsequently denied in court that an aneurism existed.

A dilated aorta can be seen from the back on the left side of the vertebral column. Bouchard says that when aortic insufficiency is present, pulsating aortic shadows are visible on both sides of the spine—that is, in the ascending and the descending portions of the aorta.

Hypertrophies of the heart are readily examined on the screen. In those of the left ventricle the apex elongates, and the clear space usually seen between the heart and liver on deep inspiration is either diminished or disappears altogether.

The screen phenomena of right-sided hypertrophy are thus described by Régnier: 'In hypertrophy of the right ventricle, the heart, drawn down at the base, tends towards a horizontal position. When the right ventricle undergoes excessive enlargement, there may be twisting around the longitudinal axis of the heart, and the right ventricle is pulled to the front. One recognises that fact on the screen because the shadow of the right heart becomes more distinct when the patient is examined from the back than from the front. There may also be a twisting of the heart around the vertical axis of the body, the base being directed backwards and the apex to the front. This twisting is

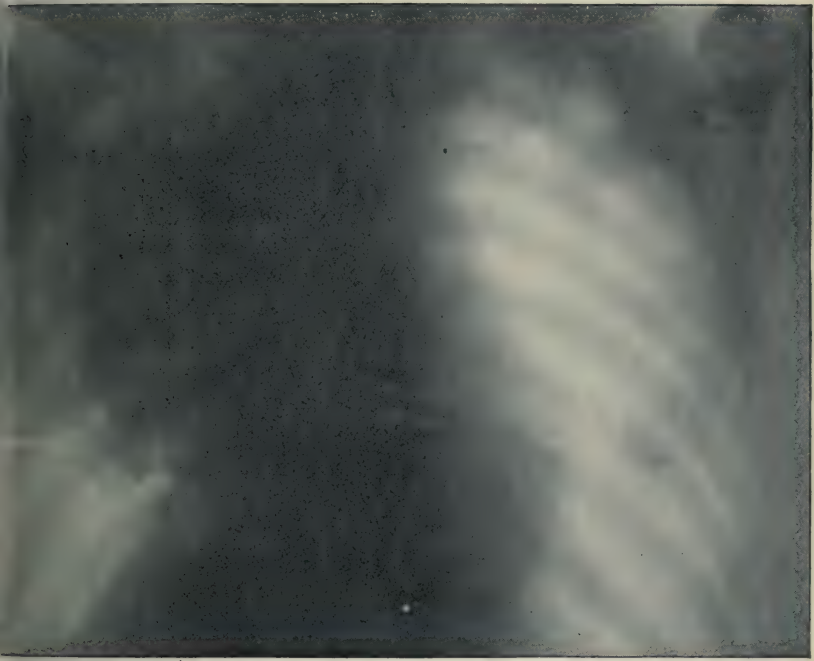

FIG. 92.—ANEURISM OF AORTA IN WHICH PHYSICAL SIGNS WERE ABSENT. (Diagnosis, aphonia from recurrent laryngeal neurosis. Large fusiform aneurism involving entire arch of aorta. J. M. Scott, M.D., *American X-ray Journal*, July, 1898.)

visible when one examines the patient from the left side: the cardiac cone is then sharply shown in its whole length. In compensatory hypertrophies of the heart from sclerosed arteries or renal cases, the auricles can be seen beating to the left of the sternum.'*

Dr. Régnier mentions a case which he saw under Professor Potain. The patient suffered from acute dilatation of the heart, and the condition was registered on several Röntgen photographs, which, in spite of their want of sharpness, nevertheless enabled one to follow the gradual disappearance of the dilatation and to preserve a graphic record of the occurrence.

Transposition of the Heart.—Many instances of this congenital abnormality have been published. When the heart is pushed over to the left side by the pressure of effused fluid, it is readily seen in its new position. An excellent illustration of a right-sided cardiac displacement in pyo-pneumothorax is given on p. 94.

Supposed Action upon the Heart.—Mr. Bezley Thorne† has made an interesting observation in relation to cardiac radiography. He noticed that the heart shrank visibly after thirty minutes' exposure to the Röntgen rays. In one case the lessening amounted to no less than 2 inches in the long axis of the viscus, and 1½ inches in the short diameter. There may, of course, be some fallacy involved in this observation. For instance, it is known that increased exposure to the rays or an alteration of current in many cases means greater penetrability of any given substance. So that the appearance of a light zone round the heart towards the end of a long exposure might mean that so much of the muscle had become fully penetrated, or that the electrical conditions had changed. In either case the dark core would probably represent blood or dense muscular tissue, or both.

Should, however, actual contraction be proved, it points to possibilities of importance. Without venturing too far afield in abstract speculations, it seems tolerably clear that, assuming such contraction, there might be direct tonic influence on heart muscle, while traumatic injury to deep organs from the Röntgen exposures might be connoted.

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* 'Radioscopie et Radiographie Cliniques,' Dr. Régnier. Baillière, Paris, 1898.

† *British Medical Journal*, vol. ii., p. 1238, 1896.

Atheroma of the Aorta

Atheromatous patches have been demonstrated in the aorta, and are usually seen better on the screen than by means of photographs.

An interesting study in therapeutics has been made by Professor Grunmach. By means of the fluoroscope he traced the action of digitalis upon the heart in aortic and mitral insufficiencies, and other conditions resulting in cardiac dilatation and hypertrophy. He also made the practical suggestion that the action upon the heart of various medicinal and toxic drugs might be studied by means of the Röntgen rays.

(*c*) Lungs and Lung Diseases: Pleurisy, Pneumonia, Phthisis

On December 7, 1896, Professor Bouchard read a paper before the French Académie des Sciences on 'Pleurisy in Man studied by the Help of the Röntgen Rays.' He pointed out that the thorax, viewed from behind by a phosphorescent screen, when traversed by the rays, showed to the right of the spine and towards the middle of the dorsal region a pulsating shadow of the heart. At the same time the liver could by means of its shadow be seen rising and falling in the chest cavity as it followed the respiratory movements. Apart from the shadows of bones, heart, and liver, the rest of the interior of the thorax was transparent.

In a right-sided pleurisy with effusion, Bouchard found a darker shade on the affected side of the chest as compared with that of the sound. Further, the shadow indicated the upper limit of the effusion, as proved by percussion and by other ordinary methods of physical diagnosis. The tint, moreover, grew deeper from the upper border, where the layer of effusion was thin, to the lower part, where the shadow merged into that of the liver.

In three cases he also noted to the left of the vertebral column a triangular shadow, the base of which was continuous with the heart. This he explained as the mediastinum pushed over sideways to the left by the effusion. In a fourth case, retraction of the affected side had drawn over the mediastinum to the right.

In a further communication to the Academy (December 14), the Professor remarked that, in most of the cases of pleurisy with effusion previously described, he had noted with the fluoroscope that the lighter area increased from above downwards as the effusion lessened. In one case, however, the apex of the chest retained its shadow. This fact suggested consolidation of the lung at that spot, a suspicion that was confirmed by percussion and auscultation. In other instances tubercular deposits were localized by the same method.

'In all tuberculous subjects,' writes Dr. Bouchard, 'examined by the phosphorescent screen, I have established pulmonary lesions by a shadow, the area of which corresponded with that mapped out by other methods of physical examination, and the intensity of which was in relation to the gravity of the lesion. In two instances the appearance of clear spaces pointed to cavities, a diagnosis verified by auscultation. But in a third case, where auscultation led one to suspect the existence of cavities, nothing of the kind was visible on the screen. In another patient the general symptoms pointed to early phthisis, but no tubercle bacilli were found in the sputa, and the physical signs were indecisive. The skiascope showed that the apex of one of the lungs was less permeable to the rays, and in a few days both auscultation and bacteriological examination of the sputum yielded positive results.'

Some no less important reports were published by the same observer in the succeeding issue of the *Comptes Rendus* (December 28). In one case the whole left lung was obscured. This appearance was attributed either to pleurisy with effusion, or to general tuberculosis of the left lung. On further examination it was noted that the mediastinum was not pushed to the right. By a process of exclusion, therefore, the diagnosis of tubercle of the whole left lung was arrived at. In another case, on the left of the spinal column in a little girl, was demonstrated a tumour, due to adenoma of bronchial glands. In a third patient, a dark shadow on the right side of the chest, continuous with that of the sternum, was shown to be due to a transposed heart. Owing to the heart's impulse being on the right side, the presence of aneurism had been suspected. Other conditions recognised include aneurism of the arch of the aorta, with a clear view of its position, outline and size; pulsation of the aorta to the right

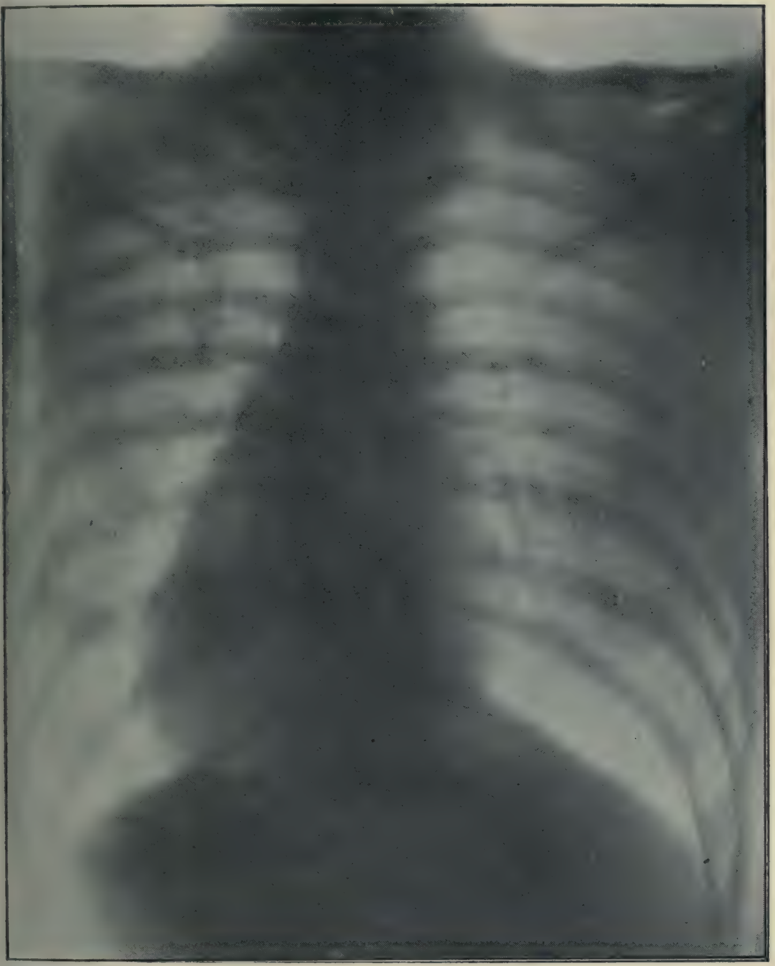

PLATE IV.—NORMAL THORAX (Short exposure).
Mr. E. W. H. Shenton. [*To face p.* 192.

and left of the sternum; compensatory hypertrophy of the heart in arterio-sclerosis; and beating of the auricles to the right of the sternum, in dilatation due to kidney disease.

Bergoiné has repeated and confirmed the above observations.*

At the Medical Club in Vienna, in January, 1897, Professor Wasserman showed two cases that he had diagnosed by the Röntgen rays. The first was a case of phthisis in the right lung, where the cavernous signs could not be elicited by percussion and auscultation. Under the rays the left side of the chest appeared clear and healthy, while the right exhibited diffuse shadows representing infiltration; in one place a clear area, which to all appearance corresponded to a cavity, was brought out by the tube when applied either in front of or behind the right lung. The second case was that of an aneurism in the left mediastinum, where the fluoroscope demonstrated a dark space, the margin of which moved with a distinct impulse, and thus established the differential diagnosis between solid tumour and aneurism.

Lévy Dorn examined with the screen the chest of a patient suffering from chronic bronchitis and asthma. He observed that the left half of the diaphragm fell rapidly at each inspiration, while it rose by slow successive stages. The right half, on the other hand, remained from the first absolutely fixed in the position of extreme inspiration, only to rise at the termination of the attack with the expectoration of viscid mucus.

Tubercle of the lungs may sometimes be found by the Röntgen rays in an early stage, when it could not be detected by ordinary means. The importance of such early diagnosis in these days of improved treatment of pulmonary phthisis can hardly be over-estimated. Another fact is that the rays not infrequently show the disease to be more extensive than had been mapped out by physical examination. When Koch's tuberculin treatment for consumption was on its trial, the writer recalls a case in which tubercle was diagnosed in the right apex, but careful and repeated examination revealed none in the left lung. The injection of the drug was followed rapidly by the appearance of a dull area at the left apex. Had the focus tube been available in that instance, there can be little doubt that the early invasion of the left lung could have been equally well demonstrated.

The localization of diseased areas in the lung is now brought within the reach of the surgeon, who has hitherto been hampered in his attempts at lung surgery by the often misleading nature of physical signs. Supposing a shadow to be fairly defined, its exact position could of course be localized by ordinary means. The altered density of tissue may show in various degrees from a slight haziness to a dark shadow; when extremely dark it is usually due to pleuritic thickening and adhesions. In tuberculous cases the collar-bone is often partly, or even at times altogether, obscured. A cavity, when empty, shows as a clear space. Pulmonary echinococcus has been noted.

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* *Gazette des Hôpitaux*, January 7, 1897.

An important case has been reported by Messieurs Varcot and Chicotot* of a child, nine and a half years of age, in whom the rays revealed a central pneumonia which was not revealed by the ordinary methods of percussion and auscultation.

The progress of the disease in the lungs can be accurately noted, and it will be possible to say with confidence whether the tubercular area has increased or decreased in size. A valuable graphic record of events can be preserved in the shape of a series of Röntgen photographs, or, failing that, of charts, mapping out the results of periodical screen examinations.

The causes of dyspnœa may sometimes be revealed by the rays when not ascertainable by other methods.

The various stages of pneumonia can be seen by the rays—consolidation, collapse, pleuritic effusion, displacement of heart, impaired respiratory descent of diaphragm. The gradual clearing up of the diseased process can also be followed.

Cirrhosis of the Right Lung with Displacement of Heart.—An interesting case of this condition has been published by Dr. Henry Waldo,† of Bristol. The patient was a boy of ten, with good family history. The heart's apex was found beating outside the right nipple; the whole right lung yielded an impaired percussion-note; and repeated examinations of the sputa failed to reveal tubercle bacilli. The Röntgen photograph showed great density of the affected lung, and absence of heart in left thorax. The case appeared to be one of diffuse interstitial pneumonia, affecting the whole lung, unconnected with tubercle, and by its contraction leading to an extreme displacement of the heart.

Impairment of respiratory movement is an important negative sign. It is shown on the screen by the lessened movement of the diaphragm, both in ordinary and in forced respiration. According to Williams,* the lessened descent of diaphragm in some cases precedes the increased density of the lungs, and is therefore to be reckoned among the earliest signs of pulmonary disease. In pneumonia, the return of normal rise and fall of the diaphragm is a more delicate test than the opacity of the lung. In emphysema the diaphragm descends lower towards the abdomen than in health, and does not rise to so high a point as it should, while the lung area is brighter than normal. In pneumothorax the diaphragm is very low down on the affected side, and motionless, except at its median end, where it sometimes moves with the sound side. The diaphragm may also be restricted in its range by pleuritic adhesions.

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* *La Radiographie*, Avril, 1899.

† *British Medical Journal*, December 17, 1898.

The diaphragm may also be pushed up, and restricted in movement by various abdominal conditions, as dropsy or enlarged liver.

A most interesting case† was shown at the Vienna Medical Club, April 20, 1898, by Dr. R. Kienbock. The patient, aged twenty-four, came from the clinic of Professor Schroetter, and had suffered for five months from pyo-pneumothorax. The published details are so instructive that they may be reproduced at some length, especially as, thanks to Dr. Kienbock's courtesy, the description is accompanied by the original illustration :

'Examination of the patient by the screen, the patient being in the erect posture, gave the following results : Corresponding to the right lung there is a long, rather light zone, the upper part of which is darker. The left half of the thorax presents altogether different appearances. The upper third is fairly light, the middle very light, while the lowest part is very dark. The upper limit of this dark field behind corresponds to a horizontal line situated two fingers' breadth above the level of the angle of the scapula. The contrast between the transparency of the middle area and the opacity of the inferior area is very marked ; but even in the latter one can make out the form of the ribs, which appear as still darker lines. The dark shadow merges below into a lighter shadow of the abdomen without any distinct line of demarcation. The shadows thrown by the sternum, the great vessels, and the vertebral column are not broader than normal. The shadow of the heart is displaced far to the right, and it can be discerned extending some distance down into the dark zone.

'It is easy to detect various movements in the image. On the right side the shadow of the liver descends several centimetres with each inspiration, while on the left the level of the dark zone ascends during inspiration for three-quarters of the width of the intercostal space. The ribs are raised with inspiration on both sides. The shadow of the enlarged heart pulsates strongly and rhythmically, corresponding to the pulse at the wrist. The pulsation can be perceived easily all over it, the lower half moving to the left during systole.

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* *British Medical Journal*, April 16, 1898.

† *Medical Press and Circular*, October 26, 1898.

'The horizontal level is continually in movement. Apart from the respiratory change of position, there are undulations which are to some extent synchronous with the contraction of the heart; but this rhythm is disturbed by irregular waves which pass over the surface at the same time. When the patient holds his breath, one can see clearly the level rising at each cardiac contraction. The slightest movements of the thoracic floor show themselves on the surface level. This remains horizontal when the patient bends over to the right side or to the left. On percussion of the thorax the undulations above described become more pronounced, and they attain the height of ten centimetres when the patient is violently shaken. They may be compared to the oscillatory movements seen in a vessel filled with liquid when it is sharply agitated.

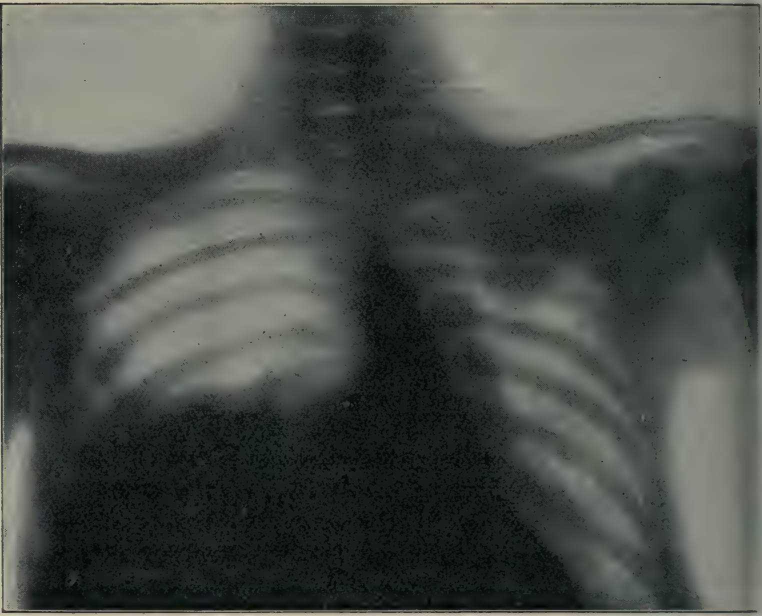

FIG. 93.

'The photograph reproduced in the accompanying illustration was taken with the patient sitting down, leaning his back against the case containing the photographic plate. The tube is 15 centimetres distant from the sternum, at the height of the surface level. The photograph reproduces very closely the description given of the image on the screen, but, of course, without the phenomena of movement.

'On examination of the patient lying down on his left side, the darker shadow is again seen undermost, but it now extends from the apex of the lungs to the diaphragm, and shows neither pulsatory nor respiratory movements. The median part of the left half of the diaphragm is visible in this position. It is obviously depressed, and does not appear to be moving distinctly. The shadow of the heart subsides to a slight extent into the left half of the thorax.

We may infer from these appearances that the right lung is diseased in nearly its whole extent, while on the left side there is pyo-pneumothorax. The comparative opacity of the right lung is to be attributed to compression, infiltration and thickening of the pleura ; the dark apex is characteristic of tuberculosis.

'The shadow in the upper part of the left pleural cavity is due to the adherent contracted apex of the left lung. Below it there is air, hence the marked transparency of this part as seen on the screen and in the photograph. The inky and lowest shadow is caused by liquid which amounts—judging from its height—to several litres. It is probably sero-purulent in character. The heart is enlarged and shifted into the right half of the thorax ; the pericardium appears to envelop it very closely. Its apex is directed to the left, and is immersed in the empyema fluid. The pulsation is strong and quick.

'These, of course, are all pathological changes which could be discovered by ordinary physical methods of examination.

'Although the Röntgen screen shows the level of the effusion two fingers' breadth higher than the limit obtained by percussion, this is very frequently observed, so that the contradiction in this respect is more apparent than real.

'The other observations on the Röntgen screen are, however, of the greatest interest. I mean the phenomena of motion ; first, the respiratory movements. There is an inspiratory ascending and an expiratory descending movement of the surface level.

'Various *explanations* of these phenomena have been suggested. I am disposed to think that the inspiratory dilatation of the right pleural cavity, by raising the pressure in the abdomen, tends to raise the paralytic depressed left half of the diaphragm.

'The second phenomenon is the *pulsatory* movement of the level. There is a wave moving from the heart to the left during its systolic contraction (*empyema pulsans*).

'The reason why the pulsation is not perceptible on the outside, either to the eye or the finger, may possibly be that the air-pressure in the pleural cavity is not sufficiently high. The elasticity of the air enables it to yield to the systolic shock of the liquid, and therefore the wall of the thorax is not concussed, in spite of the strong action of the heart ; further, the wall may be too rigid, or the pleura costalis too much thickened.

'The *third kind* of movements depend upon outside influences—the varying position of the patient, sudden movements, communicated vibrations, and particularly the great amplitude of the oscillations seen when the patient is violently shaken. We are thus enabled not only to hear, but also to see, the *succussio Hippocratis.*'

(*d*) The Abdomen

The application of the Röntgen rays to the adult abdomen has not hitherto yielded results to compare favourably with those derived from the thorax. The upper border of the liver, as already stated, can be well seen, and a hydatid tumour has been reported projecting from its convex surface ; but the lower border is rarely to be made out. The kidneys are not as a rule visible, although with a tube of good penetration, a powerful coil, and a short exposure, both kidneys and pancreas can be photographed. The stomach is sometimes faintly outlined, presumably most so when filled with gas. The intestines are at times to be dimly seen. In an experiment conducted by the present writer, a photograph was taken from a stoutly-built young officer thirty years of age.

He had been affected for many years with signs suggestive of intestinal obstruction following peritonitis. For a fortnight before the exposure he took 15 grains of bismuth three times a day. The result shows a faint outline of stomach and colon, with some coils of small intestine and sigmoid flexure. It seems fair to assume that this result may—in part, at any rate—be attributed to the opaque bismuth present in the intestine. The photograph was taken in the summer of 1897 with an Apps coil, 9-inch spark, and an exposure of 15 minutes, the patient lying on his belly.

After many exposures, the present writer succeeded in obtaining an *x*-ray record of a tumour about the size of an orange, apparently non-malignant and connected with the right kidney. The patient was a tall, stout woman, in whom the growth had existed for some years. At the time of examination the urine was normal, but the patient showed somewhat severe signs of pressure upon abdominal veins and lymphatics, and the general health was becoming affected. Hydatids had been suspected, and there were signs that pointed to possible implication of the gall-bladder. The Röntgen photograph showed an opaque mass, without detail, in the region implicated, and in that particular simply confirmed what was perfectly apparent to an ordinary physical examination. It showed, however, a point of some importance—namely, that the tumour was unconnected with the liver. A later photograph showed great detail, but diagnosis still remains uncertain with our present imperfect knowledge of many pathological shadows.

Kronberg* succeeded in obtaining Röntgen ray records of the intestines of small animals by filling the gut with metallic mercury. He also met with some success in larger animals and in the human cadaver. He suggests the use of that metal in the diagnosis of intestinal obstruction. He recommends the administration of a large dose (200 grains), which he states would be comparatively harmless, and suggests that by following its course with the Röntgen methods the seat of obstruction could be ascertained. At the same time it is claimed that the action of the mercury would be in some cases curative. He further suggests that the metal gallium might be substituted as less dangerous than mercury.

Drs. Lévy-Dorn and Boas† have introduced a method of ascertaining the position of the fundus of the stomach, the existence of stenosis of the pylorus and the intestines, and the amount of contractility possessed by the gastric and intestinal muscles. They administer to the patients a gelatin capsule filled with metallic bismuth and coated with celluloid. The bismuth being opaque to the rays and the celluloid insoluble in the gastro-intestinal juices, its position may be ascertained by means of the fluorescent screen. In most cases the capsule was seen either on the great curvature of the stomach or in the cæcum near the ilio-cæcal valve. In cases of pyloric stenosis the capsule generally remained for several days in the stomach, a point of great diagnostic value. Otherwise the capsule was passed per anum in from two to six days. If the capsule be retained in the stomach it must be removed by operation.

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* *Wien. Med. Woch.*, May 23, 1898.

† *Deutsche Medicin. Wochenschrift.*

Professor Rosenfeld, of Breslau, has obtained good results by inflating the stomach and intestines before the application of the rays.

In the case of cancerous masses of the stomach, Bouchard failed to obtain any positive result even with a coil that gave a spark of 15 inches. On the other hand, Rosenfeld reported to the Berlin Medical Congress of 1899 that he had made radiographic observations of diseases both of the stomach and of the liver in the living subject.

Murphy's buttons, coins, and other foreign bodies have been detected in the abdomen, more especially in the case of children. It is obvious that such localization might afford simply invaluable aid to the surgeon.

Calculus of gall-bladder, kidney, ureters, and urinary bladder have been often detected in the living adult. They are described more fully in the section upon 'Foreign Bodies' (p. 117). Results in each case, however, are still more or less uncertain. Much the same statement applies to the radiographic examination of the uterus, with its contents and appendages, a subject dealt with under the heading of 'Obstetrics' (p. 221).

Practical Conclusions

To sum up the applications of Röntgen rays to clinical medicine: First of all, we find that satisfactory results are confined chiefly to the thorax, although now and then useful information has been obtained from the abdomen. Secondly, in the lungs we can sometimes get early information as to tubercle, which may not be disclosed by ordinary means of physical or bacteriological examination, and effusion of fluid in pleurisy may be accurately estimated, as well as in pericarditis and in various non-inflammatory local dropsies. As to the heart and large vessels, enlargements and displacements can be readily demonstrated, together with thoracic aneurism. Such alterations can be detected when cloaked from ordinary examination by emphysema of the lung. The results of the Schott plan of treatment of heart diseases can also be followed.

One important point is the possibility of localizing patches of tubercular consolidations and cavities in the lung substance. Hitherto one of the chief obstacles to the progress of lung surgery has been the difficulty of exact localization. Thus, it not infrequently happens that the physical signs point to the presence of a cavity where that particular lesion, in point of fact, does not exist. If this diagnosis, then, could be cleared up definitely by a radiogram or by the fluorescent screen, the hands of the surgeon would be considerably strengthened in dealing with individual cases. It is hardly needful to remind the reader that the fact of a deep consolidation lying beneath healthy lung renders it extremely difficult or impossible to diagnose the trouble by percussion and auscultation.

As blood is opaque, a clot in the brain, especially if large in size and near the surface, may perhaps be radiographed.

V. OTHER MEDICAL POINTS

The Diagnosis between Gout and Rheumatoid Arthritis

In May, 1897, Messieurs Oudin and Barthélemy showed a series of Röntgen photographs of the hands and feet of patients affected with gout and with rheumatoid arthritis.* Normally the articular cartilages are transparent, and the dark shadows of the bones are separated by a clear band from 1 to 3 millimetres in width, a condition that is maintained to the end of life in the healthy subject. In gout these clear spaces are unaffected, but the disease is characterized by tophi, which appear as light patches on the denser bone. In rheumatoid arthritis, however, the clear spaces disappear, even in young subjects (see Fig. 86), and that fact, together with the bony outgrowth and deformity, furnishes diagnostic signs by the Röntgen methods.

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* *La France Médicale*, June 4, 1897.

Enlargement of the axillary glands has been seen in breast cancer.

Calcification of Arteries

As might be expected, a radiographic record can often be obtained of calcification in arteries, whether primary of the middle coats or secondary of the inner.

VI. ACTION OF THE FOCUS TUBE UPON THE SKIN AND DEEPER STRUCTURES

Soon after the Röntgen rays came into general use, as every-one knows, cases of resulting injury to the skin were reported. This ill effect was usually spoken of as 'x-ray dermatitis,' but the present writer, in a paper* read before the Dermatological Society of Great Britain and Ireland in July, 1897, ventured to suggest the non-committal name of 'focus-tube dermatitis.' By either term is meant an inflammation of the skin following one or more exposures to a focus tube in action. The damage may be fleeting, nothing more than a slight reddening of the skin, with sudden onset and rapid disappearance, or the hairs of the affected part may fall out painlessly. On the other hand, it may be severe, coming on from a few days to three weeks after the exposure; the epidermis may peel off, or the underlying tissues may slough away, and leave an obstinate ulcer that takes months to heal.

The fleeting effect of the focus tube was well illustrated in a case where the present writer took two Röntgen photographs of a lady's hand with an exposure of four minutes, and the tube at a distance of 12 inches. Some days later the patient volunteered the information that she had felt something wrong with one of her fingers ever since the taking of the photographs. On examination, the nail of the ring-digit was found in a state of partial dusky erythema. This slight traumatism would almost certainly have been overlooked had not the patient herself drawn attention to the fact.

A large number of instances of severe damage have been recorded.

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* See *Transactions Dermat. Society of Great Britain and Ireland*, vol. iii., p. 137.

[*] The existence of cause and effect in this condition has been established both by the large number of recorded cases and by certain experimental observations. Thus, Professor Elihu Thomson,[†] who was sceptical as to any such injurious action, exposed his hand for half an hour at a few inches' distance from a 'live' tube, and was rewarded by the appearance of an eruption nine days later. Then, again, it is claimed that dermatitis may be induced at will by placing active tubes of medium resistance for ten or fifteen minutes at a short distance from the surface of the body. That the reaction may often exist in a minor degree and not be recognised appears more than likely. Thus, a Röntgen ray worker whose hands were affected was surprised when the present writer pointed out the fact, especially as he had previously hinted his doubts as to the existence of such a condition. His fingers were red and leathery, and the nails, besides being brittle and broken, wanted the sharp groove that defines the lower border of a healthy nail—changes that had come on only after taking up Röntgen work. Making every allowance, however, for cases that are not recognised and for the far larger number that are not recorded, it nevertheless seems evident that the percentage of cases of dermatitis following exposure to the focus tube must be extremely small. Of late there has been a marked diminution of reported cases, a fact that appears to have some relation to the general shortening of exposures. Lastly, the affection seems to have involved an undue proportion of practical workers, who have been continuously exposed over long periods to the action of the focus tube, although the individual exposures may have been short.

There is nothing specific about the inflammation of the skin, nothing in its appearance that would proclaim it as due to the focus tube. It is a symptom of a remote exciting cause, and exactly resembles the dermatitis set up by a number of other external irritants, such as exposure to a hot sun, to a furnace, or to the action of a caustic alkali. The question before us in this particular case is the nature of the irritant peculiar to the focus tube.

If a multitude of persons be exposed to a hot sun, perhaps one out of a million will develop a severe dermatitis, exactly resembling that set up by the focus tube. In both instances there is a distinct, if imperfectly understood, *causa causans;* but something more is needed to account for the phenomenon of individual selection, and that we may express by the convenient term 'susceptibility.' In this way the extremely small proportion of persons attacked by focus-tube dermatitis may be so far explained: many are exposed to the irritant, but few are susceptible.

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[*] The next few pages are from a paper read by the author before the Röntgen Society of London to introduce a discussion, December 6, 1898.

[†] *Johns Hopkins Hospital Bulletin*, No. 71, February, 1897.

Other contributing factors are, seemingly, the nearness of the focus tube to the skin, the resistance of the tube, and the duration and frequency of exposure. These assumptions, in addition to a certain amount of evidence to be quoted forthwith, may be supported by the analogy of a hand held near a hot furnace: the nearer the hand to the fire and the oftener and the longer it be placed there, the greater will be the resulting damage. The proposition that the injurious effects of the focus tube are inversely to the distance of the tube from the skin and the length and frequency of exposure is supported by the following evidence:

1. Close proximity of tube and an exposure of ten minutes or a quarter of an hour is adopted in order to produce therapeutic or intentional dermatitis.
2. In most of the recorded cases of injury, severe or otherwise, the 'live' tube has been placed near the skin during a long time.
3. Repeated short exposures produce dermatitis in workers with the rays who are susceptible.
4. Professor Elihu Thomson's artificial dermatitis was produced by a near tube and a long exposure.
5. Negatively, no case has come to the writer's knowledge in which a short exposure with the tube at a fair distance has been followed by any seriously bad results.

These considerations seem well enough supported to help clear the ground in various directions. Thus, they show why cases of focus-tube dermatitis are so rare that their existence is denied by some persons, why practical workers are specially prone to attack, and why dermatitis has not occurred at all within the experience of some extensive workers with the rays.

Fortunately, when we come to the discussion of cases, we have a large number recorded by accurate observers. So long ago as February, 1897, Gilchrist* was able to publish a collection of twenty-seven cases. One remarkable instance under his own care was that of a demonstrator, thirty-two years of age, who, after frequent and prolonged focus tube exposures, developed a severe dermatitis. The bones of the hand became painful upon pressure, and a Röntgen photograph showed distinct osteoplastic periostitis, with a probable osteitis of the first and second phalanges of the index and middle fingers, and also of the heads of the metacarpal bones. Without endeavouring to make an analysis of all recorded cases, mention may be made of a few that raise points of special interest :

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* *Johns Hopkins Hospital Bulletin,* No. 71, February, 1897.

In the *British Medical Journal* epitome for August 15, 1896, the case of a young man of seventeen was reported. He was under the care of Marcuse, who found the patient suffering from a diffuse desquamative dermatitis of the face and back. There was also a partially-bald patch on the temple, from which the hairs could be easily extracted.

In the same journal for November 17, 1896, Dr. Drury described a case in which severe results followed two exposures, the first of an hour, the second of an hour and a half. A large surface of the epigastrium became erythematous and swollen ; it vesicated on the tenth day, and showed a profuse discharge on the twenty-fourth day. A troublesome ulcer which ensued was unhealed sixteen weeks later.

In the *Canadian Practitioner* for November, 1896, Dr. King of Toronto reported the case of a young man who for three months was engaged in demonstrating the Röntgen rays, with a daily average exposure of six hours. After about six weeks he had dermatitis of the right arm and hand, which recovered after discontinuing the exposure. On resuming work, however, he had another attack. In about six weeks the hand and face of the exposed side showed signs of a severe dermatitis. The eyelids were œdematous, and there was double conjunctivitis. On the left hand the nails exfoliated and the hairs were destroyed. On the left side the hair was gone from temple, eyebrow, upper lip, side of face, and neck.*

Dr. Radcliffe Crocker, in January, 1897, published the case of a lad who developed a large and obstinate ulceration of the abdomen after a single exposure of an hour's duration. The lower border of the inflammatory area was sharply limited by the clothing, and six weeks later a small, painful ulcer was still left unhealed.

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* For abstract see *British Journal of Dermatology*, January, 1897.

In February, 1897, Professor Waymouth Reid,[*] a highly-skilled and accurate observer, within four days underwent four exposures, of twenty, forty, fifty, and ninety minutes respectively, and afterwards suffered from a severe dermatitis in the exposed area. The skin lesions were healed by the thirty-third day, but sixty-nine days after the original exposures he reported to the present writer: 'There is no vestige of hair left upon the chest, and I have not been troubled with the shaving of my chin for the last six weeks, the hairs having come out by the bulbs to the touch of the razor twenty-two days after the chest exposure, after a slight preliminary erythema of the skin, not followed by loss of cuticle.' As always happens where the focus tube dermatitis has not caused deep sloughing of the skin, the hair afterwards grew again. Dr. Reid further placed on record the interesting fact that there was an erythema of the back as well as of the chest—that is to say, presumably at the points both of entry and of exit of the irritant rays, unless, indeed, we attribute the result to direct or indirect electrical influences.

The last-mentioned point may be compared with a case published by Mr. T. L. Gillanders, M.B. After several exposures, extending over twelve days and including screen examinations and photographs with final screen operation, the patient, while convalescing, developed dermatitis on both sides of the hand. It is not stated, however, that both back and front were not exposed to the focus tube.

Two other instances of double-surface injury are mentioned by Wolfenden[†] as having come to his knowledge.

Turning next to cases that have come under the author's personal observation, one has already been noted where congestion of a nail-bed followed twenty-four hours after a four minutes' exposure of a hand, with the tube a foot above the plate.

In July, 1897, the writer reported several instances of deep tissue traumatism. In one striking case the patient suffered from cerebral symptoms suggestive of sunstroke. For a long time he had been in the habit of demonstrating the Röntgen rays, and often had one side of his head within a few inches of a focus tube, with only a wooden screen between. From time to time he suffered from a slight dermatitis, but at length he developed more serious symptoms, of which the chief were headache, vertigo, vomiting, dimness of sight, and great prostration. He placed himself under the care of a medical man at a seaside town, and that gentleman said at the time his symptoms were practically those of sunstroke, a view that he has since kindly confirmed. If we may on such evidence ascribe the cerebral attack to the influence of the focus tube, then its influence upon deep structures must be admitted.

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[*] *Scottish Medical and Surgical Journal*, February, 1897.

[†] *Wright's Medical Annual*, 1899, p. 107.

Another case in point came under personal observation. A practical worker with the rays, a healthy middle-aged man, was carrying out a series of experiments that involved exposure of the region of the stomach for a period of about two hours daily. After some weeks he complained of abdominal symptoms, such as pain, tenderness, flatulency, and diarrhœa. He went away into the country for a fortnight, and got well. On his return he resumed his experiments, and after a fortnight experienced a second attack. He then shielded his stomach with a thin sheet of lead, and his symptoms finally disappeared. This history certainly suggests that in his case the rays of the focus tube caused a direct inflammation of the gastro-intestinal mucous membrane. Serious digestive disturbances have also been attributed to x-ray exposures by Messrs. Bergoiné and Teissier. They also hint at the possibility of pneumonia having been set up in the same way.

Another group of cases has been noted by the author, namely, those in which previously unsusceptible persons have been rendered susceptible by altered conditions of exposure. In July, 1897, he described to the Dermatological Society of Great Britain and Ireland an experience of Mr. Webster, a gentleman who has had a wide experience of Röntgen ray work. For a year or more he had undergone constant exposure to the focus tube without bad results. He then injured himself with a metol solution while developing photographic plates, and shortly afterwards a diffuse dermatitis appeared on the back of his hand. The interesting points are the previous damage of skin by the metol and the fact that the dermatitis coincided with the heating of the kathode end of the tube.

In another case kindly communicated by Mr. Webster, an individual had been exposed for something like a score of times within a period of six months. Six weeks after the last exposure the hair fell out from one side of the head. The only differing conditions of experiment, so far as could be ascertained, were that in the last, and presumably the damaging, exposure the kathode end of the Crookes' tube had been kept continuously heated.

A striking instance occurred in the person of a gentleman who had made some 2,000 Röntgen exposures, but, having seen no ill effects therefrom, not unnaturally doubted their occurrence. At the conversazione of the London Röntgen Society, held on November 21, 1898, he exposed his hand to a strange tube, and three days later developed a patch of dermatitis.

The author has twice suffered from mild dermatitis of the left hand. On each occasion the attack followed a prolonged demonstration of the rays with the hand close to the focus tube, from which several sparks passed to the skin surface.

We have thus four cases in which individuals unsusceptible to focus tube injury under ordinary circumstances became susceptible under altered conditions of experiment. The extent to which the heating of the kathodal end of the focus tube might be concerned in the result offers an interesting point for physical investigation. The kathodal rays strike the platinum anode, or anti-kathode, and often render it red-hot, and one is tempted to speculate whether their contact with the skin surface might not have a somewhat similar calorific effect. In other words, that focus-tube dermatitis may be a sort of burn.

The analogy is not a little striking between focus tube dermatitis and that produced in rare instances by a single exposure to a hot sun, or at any time by sufficiently close or prolonged contact with the heat of a furnace. With regard to all these conditions, we may observe:

1. That the dermatitis may result from a single exposure.
2. That bronzing may occur.
3. That the injury is excluded by clothing.
4. That chemical rays exist in each source of injurious influence.
5. That deep as well as surface tissues may be affected.

1. That dermatitis may follow a single exposure to a hot sun is an established medical fact. In his smaller Clinical Atlas (Plate CX.), Mr. Jonathan Hutchinson gives an excellent picture of a most severe eruption following that circumstance.

2. Another remarkable resemblance is found in pigmentation. Bronzing, as everyone knows, is a constant result of exposure to the sun; and most folk would connect the black skin of the negro with some inherited peculiarity acquired by ancestral life under a tropical sun. Bearing upon this point is the case where Despeigne used the focus tube rays to alleviate the pain of cancer, and after the eighteenth sitting found the exposed skin almost as black as that of an African negro. In this connection may be mentioned the bronzing sometimes seen in those exposed to the prolonged influence of powerful electric light.

3. The third point is illustrated by the protection afforded by clothing against sun damage, and in the case of the focus tube by Dr. Crocker's case, where the inflammation was sharply delimited by the clothing. Nor is it possible to recall a case in which either sun or focus tube dermatitis has occurred in parts protected by clothes. Clearly, this observation alone, if established, would suffice to absolve the x-rays pure and simple from any suspicion of traumatic agency, for there is no ordinary clothing which they would not readily penetrate. It is also worthy of note that an assumption of the innocence of the x-rays themselves has been implied in the attempts to prevent injury by interposing shields of indiarubber, vulcanite, and other materials which offer no resistance to the rays. One may remark, by the way, that the use of such protective appliances involves an obvious fallacy of numbers, inasmuch as persons working under unprotected conditions are so rarely attacked that the vulcanite or other screen would have to be applied in an enormous number of exposures to enable one to arrive at any trustworthy conclusion. If the gentleman already spoken of, who made the 2,000 exposures without bad results, had used a vulcanite shield, he might naturally have ascribed the absence of dermatitis to that precaution, although he would, nevertheless, have thereby strayed into a logical pitfall. A rational method would be to test the results of protected and unprotected exposures on different portions of the body of persons of proved susceptibility. It would be easy to devise a series of experiments under those conditions, planned so as to exclude all the less penetrating rays from the skin surface.

4. That chemical rays are emitted from sun, focus tube, and furnace is a simple physical proposition, capable of ready proof.

5. With regard to the fifth point—namely, that of effect upon deep tissues—that result is recognised in the case of sun-rays, and instances have been adduced to show that a similar action may be exerted by the focus tube. Other facts pointing to deep action of the latter are the relief of pain, noted by Despeigne and others, and the local tremors that not infrequently attend exposure. The writer has observed tremor of a limb in one of two feet photographed on one plate (Fig. 82). The analogy between sun and focus-tube action is amplified by a case, seen at hospital in the summer of 1898, of pronounced sun dermatitis, the onset of which was attended by fine tremors, exactly like those set up by the focus-tube.

This point of the similarity of the focus-tube lesion to that of severe sunburn is admitted by Gilchrist, who says, however, that the two things are different, because in solar eruptions there is no alopecia and no periostitis. His objection, however, does not appear altogether sound, because there is obviously traumatism to some of the deep structures in sunstroke (whether direct or indirect does not here affect the argument), and it would be impossible, so far as one can see, in our present state of knowledge to demonstrate the selectiveness or otherwise of any particular structure by that deep injurious action. Further, one would be inclined to connect the thickness of the negro skull in various ways, perhaps both individual and inherited, with prolonged exposure to tropical suns. The following observation, if confirmed, would point to the protective nature of the negro skin. Mr. Albert Walsh, of Port Elizabeth, communicated to the writer that he could not detect a bullet in a black man's thigh, although his apparatus was in good working order, and produced good results in the case of a white man. This observation he has since confirmed, and imagines there may be some special resistance offered to the rays by the colouring matter of the negro skin.

In the first edition of this book the view was expressed that, 'on the whole, it seems not improbable that some common agent exists in the rays of the sun, of the focus tube, and of the electric arc light capable of stimulating the human cutaneous surface, and sometimes the deeper tissues of the body, in varying degrees of severity, which are in some way determined by personal predisposing peculiarities.'

A curious confirmation of that hypothesis has been since advanced by Professor Schiff at the Austrian Gesellschaft der Aertzis.* At that society he showed a patient who had been treated with the focus tube rays for lupus. He attributed the successful result to the chemical action of the rays, and quoted Finsen of Copenhagen, who recorded equal success with rays not produced by Röntgen apparatus. His statement was confirmed by Spiegler, who said he had worked personally with Finsen while carrying out the treatment in question. The sun's rays were usually utilized for the purpose, and were passed through lenses to decompose the light before it was allowed to reach the morbid structures. At a later stage of the experimental treatment an electric arc light was used. 'Little glass plates were laid over an illuminated surface, to produce a sort of anæmia, or the acting ray would have checked the circulating blood altogether.'

It may here be stated generally that the view that the injury is not caused by the *x*-rays, but by some accompanying influence, appears to have gained most favour in France, Germany, and America.

Various theories have been advanced to explain focus-tube dermatitis. Of these the chief attribute the bad results to:

1. Ozone generation in the skin.
2. Flights of minute platinum atoms.
3. Ultra-violet rays.
4. Radiant energy.
5. Rays of *x*-ray order most readily absorbed.
6. Electrical induction.
7. De-electrification.

1. Tesla's view, that the damage is due to ozone generated in the skin, does not account for injury to deep tissues, if we accept that result.

2. There does not appear to be any general acceptance of the theory of the projection of streams of solid particles through the walls of the tube.

3, 4, and 5 may be taken together; the term 'chemical rays' is perhaps wide enough to include them. Dr. Philip M. Jones, of San Francisco, in a paper read before the California State Medical Society, April 20, 1897, attributed the dermatitis to the absorption of radiant energy by the cells of the skin, and thought the process parallel with the changes effected in the photographic emulsion. He agrees with the majority of observers that a bad result is more apt to follow exposure to a tube of low than of high vacuum. The latter fact further tends to exonerate the x-rays, for, as Mr. Gardiner has demonstrated to the Röntgen Society,* 'the greatest production of x-rays takes place in tubes of high resistance'—that is to say, the very tubes that, according to most authorities, are the least likely to do harm. Under the same heading of radiant energy comes the contention of Elihu Thomson, that 'the burns are produced chiefly by those rays of the x-ray order which are most readily absorbable by the flesh.'

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* *Medical Press and Circular*, November 23, 1898, p. 540.

6. The theory of electrical conduction appears to be controverted by an experiment of Elihu Thomson's. In a sheet of lead he cut a window, which was divided in two by a strip of tinfoil; one of these he covered with a double layer of aluminium foil, while the other was left bare. This compound shield he placed on a finger, and exposed it to the action of a focus tube. Two burns resulted, one on the part under the aluminium foil and the other on the bare spot. Professor Thompson thinks it inconceivable that any electrostatic effect could have been produced through the aluminium foil more than through the tinfoil or the lead, as all three metals were in electrical contact and subjected to the same conditions.

A further argument against the induction theory may be found in the great amount of harmless electrification of skin often involved in therapeutic or experimental work. At the same time, it seems likely we have yet to learn a good deal about the electrical states that are set up thereby in the skin. In that structure we find externally a thin, hard, horny, non-conducting layer, which lies upon the middle layer of so-called 'prickle' cells, which are bathed in serum, a warm salt fluid. The prickle cells are cut off by the close layer of columnar cells known as the 'palisade' layer from the underlying tissues, charged with warm alkaline blood and serum. All these layers are pierced by the hairs and the sweat-ducts, both hair-bulbs and sweat-glands being in the deeper tissues. When this combination of solid and fluid tissues is injured by exposure to the action of the focus tube, there is a tendency to pick out certain structures, as the hair-bulbs and the palisade layer. In cases of moderate damage, the brunt of the mischief is borne by the palisade layer and by the hair-sheaths. As regards the hairs, one might almost imagine they had acted as conductors of some injurious electrical agency either to or from the body; any way, the reason why hairs alone should be selected by the focus tube is not apparent. The anatomical arrangement of the skin would appear to favour complicated electrostatic conditions. Lastly, it is a noteworthy fact that under certain circumstances the sweat may become acid, a fact which may have a bearing upon the little-understood problems of individual susceptibility.

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* *Archives of the Röntgen Ray*, May, 1898, p. 70.

7. De-electrification, suggested by Dr. Lowe of Lincoln and others, an action known to be brought about by the rays of the focus-tube. This hypothesis might explain the very peculiar inflammatory selection of the hairs already spoken of.

The following propositions seem to be fairly well established:

1. A dermatitis of varying severity, with a tendency to destroy hairs, the deep layer of the epidermis, and the subcutaneous tissues, may be set up by exposure to a 'live' focus tube.

2. The particular damage usually follows either a number of short exposures or a single long exposure with the tube close to the skin.

3. While the injury as a rule affects susceptible people only, it may, nevertheless, be induced at will under certain conditions in any individual.

4. The inflammation is probably due, not to the x-rays pure and simple, but in some way to chemical rays generated in the focus tube, or to electrical conditions produced in the skin, or to a combination of those agencies.

Many other similar cases have been recorded. When the rays are directed upon the scalp, they appear to cause shedding of hair without any severe reaction. The nutrition of the hair-bulb is interfered with, possibly by some vascular changes leading to exudation and intrafollicular pressure. At the Vienna Gesellschaft, in January, 1897, Zemann stated that he found many different changes in hairs that have been treated by the Röntgen rays. The hair-root was always thinner, and the shaft brittle; the hair itself might be of the usual thickness, or often cone- or spindle-shaped, with fibrous swellings. At the same meeting, Kaposi remarked that the hairs shown by Zemann were like those met with in the microscopic examination of alopecia areata, and he thought them due to a similar pathological change. This last point is interesting as tending to throw some sort of side-light on alopecia areata. It would seem that by bringing a focus tube near the scalp, and exposing the latter to a somewhat prolonged action of the rays, we can produce an artificial *area*. Not only that, but we have the high authority of Kaposi that the pathological hairs resulting from the ray exposure cannot be distinguished from the diseased hairs of alopecia areata.

The tendency of most observers now appears to be towards the view that the dermatitis has a distinct relation to the length and frequency of the exposures, as well as to the distance of the focus tube from the skin surface.

Lastly, we have the important influence of idiosyncrasy. Many people are exposed both to hot sun and to Röntgen ray demonstrations, but comparatively few suffer in consequence. Predisposition of some kind appears to be an absolutely essential factor. The peculiarity may lie in the skin, but it seems more likely to be in the blood, especially as the latter is attracted to the skin in greatly increased volume in response to many external irritant influences. It may be that the focus tube rays, like the sun and other external irritants, stimulate the excretory function of the skin into unusual activity, and that the outward passage of some irritant from the blood sets up the dermatitis.

Mr. C. Mansell-Moullin, Dr. Lewis Jones, Dr. Wolfenden, and others seem inclined to attribute the injury to deep nerve and vaso-motor disturbances.

On the whole, it seems not improbable that some common agent exists in the rays of the sun, of the focus tube, and of the electric light, capable of stimulating the human cutaneous surface, and sometimes the deeper tissues of the body, in varying degrees of severity, which are in some way determined by personal predisposing peculiarities.

VII. THERAPEUTICS

The possible curative action of the focus tube rays has given rise to many proposals. There can be no doubt that under some imperfectly understood conditions they are able to exert considerable influence on the cutaneous surfaces of the human body.

Whether this be due to the unmixed Röntgen rays, or to a ray of some other kind, need not be further considered here. It seems clear that rays of various qualities are combined in their exit from the Crookes' tube, but they must be treated as a whole in considering their effect upon living tissues. At first it was generally assumed that the effects, varying in degree from simple congestion to severe destruction of tissue, have been confined to cutaneous surfaces. More recent observations, however, point to an action of the Röntgen rays upon the deeper parts of the body.

The belief appears to be now pretty generally accepted, that a cutaneous inflammation can be produced at will by the prolonged exposure of an ordinary focus tube at a short distance from the skin. As a surface caustic, however, the focus tube does not appear to have a remote chance of coming into general use among dermatologists, for reasons that will readily be recognised by the medical reader.

There are two affections in which this method of destructive treatment has been advocated, namely, hypertrichosis and lupus. As regards hypertrichosis, or superfluous hair, in mild cases, after a focus tube exposure the hair falls out with little or no inflammatory reaction, simply to grow again after the lapse of a longer or shorter period. On the other hand, when a severe dermatitis is set up with sloughing of the parts, the wound may take months to heal, and the hair will grow again after recovery unless the cicatrization is so deep as to have completely destroyed the hair-bulb area of the subcutaneous tissue. The latter event must necessarily be attended with unsightly scarring, as would occur in a burn of an equal degree of severity. The following instance of the mischief that may be caused by attempts to apply this treatment came under the notice of the present writer: A lady, afflicted by an abundant growth of hairs on the lower part of the face, applied to a non-medical operator with the *x*-rays. Her chin was subjected to four exposures of about half an hour each, with the focus tube at a distance of 6 inches from the face. The first two exposures were made on successive days, the third and fourth each after a clear interval of two days. Some ten or twelve days after the commencement of this treatment a severe inflammation of the chin set in, attended by much sloughing and lasting for months. The hairs came off, but the lower part of the face was covered with a deep scar, such as would result from a burn, and became the seat of a chronic irritating and eczematous type of inflammation.

In a case of the above kind it may be well to note that the person who applies the treatment may place himself in a false position. As he is not a medical man, and is applying treatment not generally recognised by the medical profession, he would possibly be mulcted in heavy damages should the patient bring an action against him for personal injury. He would hardly find a specialist in skin diseases ready to endorse the practice.

It may, perhaps, be added that there is only one scientific method yet available for the removal of superfluous hairs, namely, their destruction by electrolysis. This plan, though tedious, and applicable only when the growth is scattered, has the supreme advantage over chemical depilatories and mechanical epilation that, if properly performed, it is not followed by regrowth.

Drs. Schiff and Freund* remove superfluous hairs with a current that does not exceed 2 ampères and a tension of 11½ volts. The tube is placed at 20 to 25 centimetres from the skin for an exposure of ten minutes, and is applied for thirteen to seventeen sittings. In some of the cases it was noted that the skin showed a brownish discoloration, and black hair turned white before it fell out. For the treatment of lupus vulgaris a current of 3·5 ampères and 12·75 volts was used with the tube at 10 centimetres distance.

Turning to lupus, we find ourselves faced with somewhat similar considerations. That the malady may sometimes be cured by exposure to a focus tube is undeniable, and the focus tube must be allotted a place in the list of remedies, especially in obstinate and ulcerative cases. At the same time, the fact must be borne in mind that it often disappears under various approved forms of treatment, such as scraping and caustics, and even of internal medication. The present writer has used the focus tube rays in the treatment of lupus of the nasal mucous membrane inaccessible to ordinary methods of treatment.

Dr. Thurstan Holland reported one case of lupus vulgaris of five years' duration, that had been subjected to scraping and other forms of treatment. Eighteen exposures of fifteen minutes each were made, extending over a period of two months. The ulcerated lupus patch healed entirely, and three months later was free from recurrence. Dr. Holland has also reported excellent results in the treatment of chronic ulcers by the same plan.

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* *Wien. Med. Wochen.*, Nos. 22, 24, 1898.

Dr. J. Rudis-Jicisky* reported the cure of a case of lupus erythematosus of the leg by frequent short exposures. The healthy tissues were protected with stanniol, and the tube was placed at a distance of from 15 to 18 inches from the skin. He also found markedly beneficial effects in the treatment of ulcerative lupus vulgaris.

Freund† has applied the method with some success to an extensive nævus pigmentosus pilaris in a child. Whether the depilation thus obtained can be rendered permanent remains to be seen. Certainly, in the cases hitherto reported the hair has sooner or later reappeared. Again, there is no certainty in the resulting depilation. Dr. Low has informed the writer that he tried on various occasions to depilate a hairy mole in a child sent to him for treatment, but without success.

It is evident, then, that we have in the focus tube rays an agent capable of acting powerfully upon the skin and its appendages. At the same time, while similar effects can be obtained by simpler and safer means, the action is so uncertain, so difficult to regulate, and so apt to be attended with serious complications, that it is not likely to have any but an extremely limited application to the therapeutics of the cutaneous surface.

Deep Therapeutic Action

Turning next to the possible therapeutics of the focus tube rays upon the deeper structures, we find ourselves confronted with several interesting and suggestive facts, in addition to the deep tissue traumatism already spoken of (p. 206).

In some instances exposure to the rays has been followed by a cessation of pain, but the casual relationship between the two conditions can hardly be regarded yet as scientifically demonstrated. Probably the first notice of the kind was by Dr. Richardson‡ of Boston, who wrote to a medical journal on August 31, 1896, describing the results of an examination by the rays. The patient was a stout woman of fifty, who had been complaining of pain on and off in an old fracture near the ankle-joint. She had an exposure of five minutes, and three weeks later wrote stating that, in the interval, not only had she been free from pain, but that swelling and soreness had also disappeared.

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* *American X-Ray Journal*, October, 1896.

† *Medical Press and Circular*, January 27, 1897.

‡ *Boston Medical and Surgical Journal*, September 3, 1896.

A striking case has been recorded by Dr. Stern of Philadelphia, who detected a fragment of steel in the vitreous by means of the rays. Almost coincidently with the exposure there was a cessation of pain, so that the patient could both work and sleep.

M. V. Despeigne,* of Lyons, reported a case under the care of L. Voight. The patient suffered from a small epithelial cancroid nodule of the mouth. The rays were applied twice daily for periods of half, and sometimes a quarter, of an hour. The pain, which had been considerable, almost immediately ceased, so that the medical attendant was enabled to discontinue the morphine. The patient died eventually of pneumonia, but a prolonged palliative effect had followed the effect of the rays.

In a previous case in his own practice, M. Despeigne found that a cancer actually decreased in volume under the influence of the focus tube. His conclusion from both cases is that, when applied to cancer, the rays have a distinct anæsthetic effect, and cause a general improvement in the condition of the patient, but exert little influence upon the growth. If this be the case, surgeons will be provided with a new anæsthetic for the relief of malignant growths far less disastrous in its general results than the evils incident to morphinism.

Relief of pain has been reported by Gocht in trigeminal neuralgia and mammary sarcoma.

Some observers have also met with success in the treatment of elephantiasis.

There have been many unfounded rumours as to the action of the Röntgen rays upon blind eyes. It seems, however, that where the optic nerve remains intact the visual sensations can be excited by the rays transmitted through media that have become opaque to ordinary light, as in cataract. The scanty nature of the evidence as to the action of the rays upon the optic nerve-endings may be gathered from the following reports :

The case of a blind man was reported to the North-Western Electrical Association by Mr. Hoskin. The patient was unable to see the light of an arc lamp close to his face. His eyes appeared normal, but he had been completely blind for two years. On being placed before a Röntgen apparatus in action, he was able to describe the general outline of the tube. A sheet of cardboard interposed cut off all visual impressions.

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* *Lyon Medical Journal*, December 28, 1896.

In this case, accepting the above statements, as Röntgen rays penetrate cardboard, any visual stimulation must have been due to some other kind of ray. If the media were transparent, and the optic nerve insensitive both to day and to ordinary electric light, then it follows, if the focus tube rays stimulated the nerve, that there must be special nerve-endings excited by the rays, although not by ordinary light, supposing the action to be local. Of course, it is not impossible that the rays might have penetrated the brain and stimulated the perceptive centres. In that case, however, we should expect to have had a similar phenomenon recorded by non-blind persons; beside, there is no reason why the figure of the tube should be fixed on the perceptive centre. In short, the case does not bear analysis.

Professor Fox,* of Philadelphia, stated that a patient with corneal opacity saw nothing with an Edison's fluoroscope, whereas with the naked eye he could accurately describe the phosphorescent colour of a Crookes' tube. He conjectures that Röntgen rays will not pass through cicatricial corneal tissue. If correctly reported, this opinion seems to be based on a confusion of fluorescence (both of screen and of tube) with the actual Röntgen rays.

The retina, it should be borne in mind, is a transforming apparatus which stands between outside rays of light and the percipient nerve and nerve centres. There is, again, a purely psychic blindness of hysterical nature, and any strong impression might cause a person affected in that way, not only to see for a time, but to be permanently cured. Clearly, were an experience of that kind to be encountered by an experimenter unversed in medical matters, he might well imagine he had found a talisman for sightless orbs, and telegraph to that effect across the Atlantic.

This subject was investigated by Professor Murani, of Milan. He took five patients, of whom one had been born blind, two had acquired that condition, and the remaining two perceived light but could not distinguish objects. When placed before an active focus tube, the visible light of which was cut off by a sheet of black cardboard, the results with all five were negative. When exposed to brilliantly-lighted screens of platino-cyanide of potassium and tungstate of calcium, three perceived nothing; but the last two saw the glimmer of the screen, and one could count the shadows of the finger-bones of the hand, although he could not distinguish the form of keys.

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* 'Ulcers of Cornea,' lecture, October 30, 1896, *Medical Bulletin*, Philadelphia.

It may be concluded, then, that the focus tube will not restore sight to the actually blind.

Effects of X-Rays in Colour-blindness

It has been stated in various quarters that the x-rays had a peculiar effect on the retina of colour-blind persons. In order to test the assertion, Mr. Sydney Stephenson and the writer made the following investigation.

Four colour-blind children were tested, two of them aged eight, one nine, and the fourth eleven. They were defective to red-green; their form-sense was normal, and their intelligence good. An ordinary bianodal focus tube, and a 12-inch induction coil, working at 9 inches, were used.

Perception of light and form proved normal when tested by the screen enclosed in a bellows fluoroscope. When the children looked steadily at the fully-lighted bare tube, they showed no signs of photophobia or dazzling. They all recognised objects, such as keys, when held against the bare tube or against the screen. The after-phosphorescence of the tube was seen by all of them, as well as the greater intensity of the area of the tube in front of the anti-cathodal plane when viewed sideways. Lastly, there was no sensation of light when the eyes were shut and bandaged, and the children put in front of the live tube.

To sum up, there was no reason to suppose that the retinæ of these colour-blind children reacted to the Röntgen rays in any way differently from those of ordinary people with full colour-sense.

Effects in Tuberculosis

Messrs. Lortet and Genoud* have experimented on guinea-pigs, with a view to ascertaining whether the tube rays had any restraining effect upon acute tuberculosis. Eight of those animals were inoculated with tubercle culture, and three submitted daily to the action of the x-rays. At the end of six weeks the latter presented considerable differences from the others that had not been so treated. Those that had undergone the exposures had no abscess at the point of inoculation, the glands were well defined, and their generally good condition was proved by an increase of weight. On the other hand, the inoculated guinea-pigs that had not been under the rays showed abscess at the point of inoculation, enlarged glands, and bad general condition with loss of weight.

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* *La Revue Scientifique*, J. L. Breton, p. 106; Paris, 1897.

Mr. Brunton Blaikie, of Edinburgh,* found that the Röntgen rays had no visible action upon the growth of cultures of tubercle bacillus (see p. 174). He also found that guinea-pigs inoculated with diphtheria toxine, and exposed to the rays, lived actually a shorter time than those not exposed.

These experiments are worthy of further careful investigation.

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* *Lancet*, July 25, 1896.

E. OBSTETRICS AND GYNÆCOLOGY

OBSTETRICS

At first it was hoped that the Röntgen rays would prove of great service in obstetric medicine. In practice, however, up to the present time, experimenters have found its application to the pregnant uterus surrounded with many difficulties. The chief obstacles are: (1) The thickness of the parts to be penetrated; (2) movements, abdominal, uterine and fœtal; (3) the difficulty of keeping a pregnant woman for any length of time in a constrained position; (4) the distance of the uterus and its contents from the sensitive plate. However, when our methods have improved, there is every hope that, with a short exposure and tubes of strong penetration, the rays will furnish obstetric physicians with an additional means of exact investigation, not only as to maternal condition, but also as to the position, and even the sex, of the child.

The advantages of a good pelvic record of the kind are so obvious that they need hardly be mentioned at length. It would be possible, for instance, to ascertain the presence of twins, superfœtation, lithopædia, monstrosities, fœtal deformities, and malpresentations; while in any case pelvic deformities and exostoses could be demonstrated with ease and certainty. The demonstration of moles and of extra-uterine fœtations offers another attractive field of research.

There is one direction in which Röntgen diagnosis may prove of the utmost value to the obstetrician, namely, in the exact estimation of pelvic diameters and deformities. By means of localization precise measurements of all the bony outlets can be obtained, and the desirability of inducing premature labour or the necessity of removing a full-term fœtus by operation thereby indicated. This fact reduces pelvimetry to an exact and easily applied art. In France much attention has been bestowed upon this practical point by Professors Budin and Pinard. A stereoscopic view of a pelvis, it may be added, furnishes the observer with a perfect apprehension of the relation of all bony structures.

When taken from the uterus, an x-ray photograph can be readily obtained of the fœtus, such as that shown in 1896 by Dr. Oliver. His patient, a woman of thirty-nine, was diagnosed as having an extra-uterine fœtation, some two months beyond full term. An unsuccessful attempt was made to secure a record of the tumour in the living body. Upon operation an ovarian sac was removed containing a nine-months fœtus, of which the accompanying excellent picture was obtained (Fig. 94). The interesting observation was made that the ovarian sac was very opaque to the rays. Since then many similar photographs have been published of the human fœtus in various stages of development.

A further important contribution to the study of fœtal radiography was made by Professor Davis, of Jefferson College.* He published a radiogram which showed a faint tracing of the fœta skull, contrasting strongly from the dark pelvis in which it had been placed. He further pointed out that the fœtal skull generally except some portions at its base, offered little resistance to the Röntgen rays.

The same observer, moreover, after several unsuccessfu attempts, succeeded in obtaining a faint outline of the fœtus in the living uterus. The fœtal shape could be recognised, and the position of the limbs was evident, but the head was hidden by the maternal pelvis. No fœtal skeleton could be distinguished The experimenter concluded that the fœtal body and limbs were differentiated by the rays from the darker uterine walls and amniotic fluid.

Other observers have arrived at more or less similar results.

Thus, Imbert showed at the Montpellier Congress of Medicine a record obtained from a young woman of twenty-five, in whose case Professor Tedenat had diagnosed extra-uterine fœtation Several of his *confrères*, on the other hand, suspected a hæmatocele or a tumour. All doubt was done away with by the Röntgen photograph, which clearly showed the existence of a

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* *American Journal of the Medical Sciences*, March, 1896.

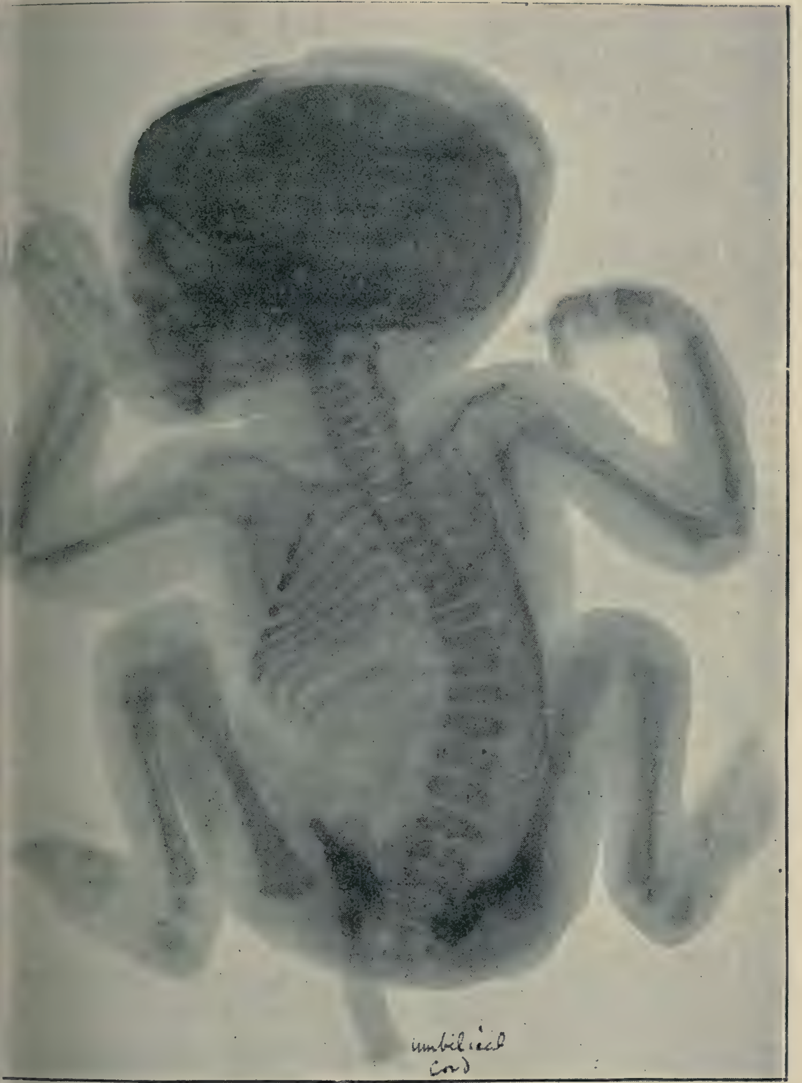

FIG. 94.—FŒTUS FROM AN EXTRA-UTERINE FŒTATION.
Dr. Oliver's case.

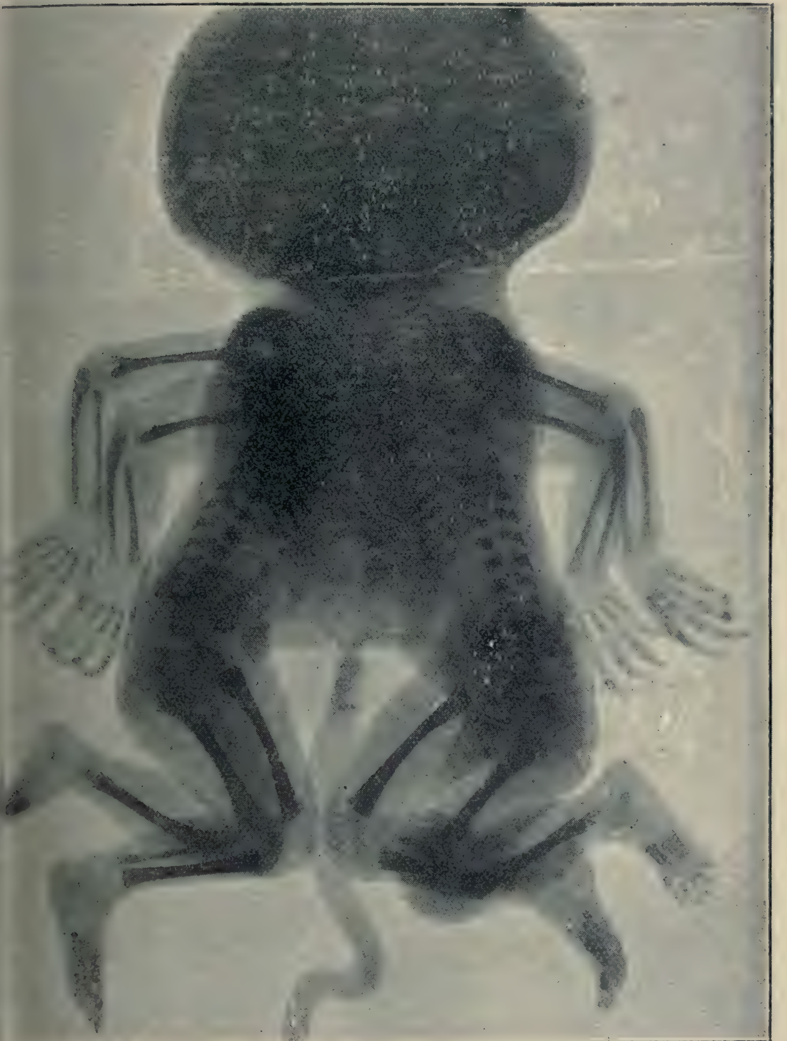

Fig. 95.—Fœtal Monster.

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five or six months fœtus, of which one could see the head, the trunk, and the lower limbs.

M. Varnier showed to the Paris Society of Gynæcology and Pediatry, on March 31, 1899, a dozen radiographs showing the position of the fœtal head in the living pregnant uterus. They were obtained with exposures of three minutes.

Messrs. Chappuis and Varnier, quoted by Dr. Mandras (Paris Thesis), took a Röntgen photograph directly after death of a guinea-pig far advanced in gestation. They obtained details of the maternal pelvis and silhouettes of four fœtuses. Negative results were obtained from a chloroformed guinea-pig.

The same experimenters showed the possibility of getting good anatomical and pathological results with the rays from the gravid uterus after removal, both when hardened in alcohol and when frozen.

Messrs. Varnier and Chappuis have obtained a Röntgen ray picture of several fœtuses in the uterus of a living guinea-pig.*

Most interesting *x*-ray pictures can be obtained of fœtal monstrosities, after removal from the body, which convey anatomical information that could otherwise be obtained only by a tedious and difficult dissection. The illustration of a two-headed fœtus shown in Fig. 95 was taken from a photograph by Mr. Lynn Thomas.

In the case of conjugate twins that survive and grow to maturity, such as the Siamese Twins and the Two-headed Nightingale, it is likely that the rays might afford pictures o much anatomical interest.

At the end of the year 1896, Dr. Davis summed up the position of fœtal radiography as follows: ‘The writer's experiments with the Röntgen rays upon pregnant women showed that it is perfectly possible to obtain an outline of the living fœtus in the body of the mother. The difficulties to be surmounted are the thickness of the tissues and the distance at which the Crookes' tube is necessarily placed from the fœtus itself. Anatomical specimens of uteri and their contents, removed from the body, should occasion no difficulty whatever. By varying the electric force employed and the time of exposure, it is undoubtedly possible to obtain a useful picture of the contents of the living womb.’

In France a special means of examining the pelvis by means of an instrument called the endodiascope has been introduced by Bouchacourt. A long metal shielded prolongation of a focus tube is passed into vagina or rectum. It is open to question whether sufficiently good results cannot be obtained by less complicated procedures.

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* *British Medical Journal*, May 30, 1896.

GYNÆCOLOGY

As methods improve, there is every reason to hope that valuable information will one day be obtainable, by means of the focus tube, as to many pathological conditions of the soft tissues of the pelvis, such as ovarian tumours, fibroids, sarcomata, and various malformations. At present the shadows obtained are too diffuse and lacking in detail to afford much help to the gynæcologist.

F. LEGAL MEDICINE

In a number of cases Röntgen-ray photographs have been produced in the law-courts. The evidence they afford is mainly corroborative, and must be taken as furnishing grounds for the testimony of expert witnesses. Their special value is that exact evidence apparent to the senses of everyone concerned is rendered available by the use of unerring scientific apparatus. With the average juryman an ounce of such fact is likely to outweigh a ton of theory obtained from roundabout deductions. To put the matter in another way, the testimony of a general practitioner armed with a corroborative Röntgen photograph would go far towards upsetting the contradictory statements of the most highly-skilled surgeon, provided the opinions of the latter were based upon nothing more tangible than the ordinary methods of examination. This point has been ably insisted upon by Mr. Howard Marsh* in the following passage: 'The information given by this method may be absolutely conclusive, and may directly contravene the best opinion that the most highly-qualified observer has had it in his power, under the difficult circumstances of the case, to form. With a photograph before him, any layman can see what by any other means could be only a matter of probability, balanced by other probabilities of almost equal weight.' The latter sentence describes the precise position of a juryman called upon to settle the nature of an injury in the face of conflicting skilled testimony. To such a man an x-ray photograph would often indicate a simple way out of the difficulty.

Dr. Richardson, of Boston, has quoted the following views of an American judge: 'It is the opinion of some of the judges of Massachusetts that x-ray photographs are not admissible as evidence. One judge holds that it has not been demonstrated as a scientific fact that they are accurate. The process has not become such a matter of common knowledge that the court will take judicial notice of it. No man can tell by ocular or other sensory evidence that the reproduction is accurate. The truthfulness of the photograph is a matter of reasoning.'

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* Technique des Rayons X,' A. Hébert, Paris, 1897, p. 105.

In considering the foregoing passage, which is a readily-understood, cautious legal attitude, it should be added that the opinion does not appear to be generally shared by other American judges Broadly speaking, expert witnesses will, as a rule, be able to assume a strong position as to the absolute value of evidence derived from the Röntgen rays. Scientific evidence, it should be noted in this connection, is daily tendered and accepted in court with regard to new drugs and other medical discoveries, while photographs, in Great Britain, at any rate, have long been admitted in evidence.

The radiograph may be valuable in any of the following medico-legal points arising in civil or criminal cases :

1. Evidence of injury, or of the presence of a foreign body.
2. Evidence of bodily identification.
3. Evidence of pregnancy.
4. Evidence of age of fœtus, or of live birth.
5. Evidence of death.
6. Evidence in action for malpraxis.

I. EVIDENCE OF INJURY

It is clear that the presence either of a foreign body, as a bullet, or of an injury to bone, such as a fracture, can be clearly proved by means of a radiogram. In some cases this may be taken a long time, very many years, after the original accident or injury. Thus, a fracture often leaves a lifelong and unmistakable record of its occurrence, and a dislocation may be photographed by the Röntgen rays at any time previous to its reduction.

Already numerous cases have occurred where x-ray evidence has been produced in court. One such instance was mentioned in the *British Medical Journal* for June 6, 1896, where a bullet in a hand formed the object of a criminal prosecution.

A case occurred early in 1897 in Dunfermline. A boy was accidentally shot by a rifle discharged by an unseen person at a great distance. The presence of a rifle bullet buried in the boy's lung was admirably shown by a radiogram taken by a local operator. In that case the man charged was dismissed for want of exact identification with the person who fired the shot.

An important trial has been reported from America.* The charge was one of murder against a man who, on July 8, 1897, shot his wife's paramour in the head with a revolver. The wounded man was taken to a hospital, where, on the fifteenth day, his temperature, pulse, and respiration sank to a nearly normal condition, and he recovered so far as to be able to walk about the wards. He was then put under ether for fifty minutes, and a Röntgen exposure made for thirty-five minutes. The tube, placed at a distance of one and a half inches from the skull, was excited by a Holtz static generator, with a capacity of half a million volts. No picture of the bullet was obtained. Within a few hours of the exposure the temperature rose from normal to 100·4° F. From that time to his death on August 12, twenty days, his temperature fluctuated between two degrees above to a little below normal, with a rise at death. The medical man who made the post-mortem examination reported to the coroner that, in his opinion, deceased came by his death from injuries to the brain caused by a gunshot wound, anæsthetics, and the x-rays.

Nowadays, fortunately, long exposures and closeness of tube to object are not required in the radiography of the skull.

Generally speaking, in any action for injury due to negligence, if a bone be fractured or displaced, the plaintiff may obtain valuable corroborative evidence from a Röntgen photograph. Or the defendant, on the other hand, may be enabled to show thereby that the plaintiff's injury is exaggerated, misrepresented, or non-existent. A careful distinction must be made as to the injuries of soft tissues, which are rarely shown by the Röntgen methods, but are often just as disabling or fatal to the patient.

II. EVIDENCE OF IDENTIFICATION

The x-rays may be useful in several ways in identifying both the living and the dead. For instance, they may prove the presence of former injuries, such as fractures. In the well-known case of Dr. Livingstone, the African explorer, an x-ray picture of the false joint in the arm due to the bite of a lion, an injury from which he was known to have suffered, would have afforded valuable corroborative evidence of identification.

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* *American X-Ray Journal*, March, 1899.

Another way in which the rays might be useful would be in determining the age of a body up to early adult life, from the union or non-union of bony epiphyses. Any conclusions on this point, however, would have to be formed with a due regard to the varying ages of epiphyseal union. Observations so far show that, apart from early bone disease, there is apparently a good deal of individual difference in the time of fusion of epiphyses. This point is dealt with more fully in a later section on Anatomy.

Professor Amoedo proposes to take the measurements of the pulp-cavities of the teeth as a test of age. He states* that in 1844 Carabelli, of Vienna, Kory in 1885, and Boedeker, of New York, in 1894, made investigations on this point, but were obliged to work by the laborious method of cutting sections. Thanks to radiography, however, a number of teeth may be measured exactly within a short time. He points out that the pulp-chamber of the first molar is smaller than that of the second, a fact which he attributes to its prior eruption by six years, as one knows the cavity enlarges with age.

III. EVIDENCE OF PREGNANCY

Up to the present some uncertainty attends the diagnosis of pregnancy by the Röntgen rays—at any rate, in the early stage of the living subject. It may be stated, however, that a good picture of the fœtus may be obtained *in utero* after removal from the body. Moreover, an outline of the fœtus has been frequently obtained by several experimenters in the living subject. One result of a more perfect process would be to enable the English criminal law to replace by exact scientific methods the 'jury of matrons,' whose verdict decides whether a woman condemned to death is pregnant or otherwise. Even in these modern days, the question is on rare occasions still settled by that ancient tribunal.

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* *Les Rayons X*, 2 Avril, 1898, p. 5.

IV. EVIDENCE OF AGE OF FŒTUS

A perfect Röntgen record may be obtained of a fœtus after removal from the uterus. In this way the stage of ossification can be exactly estimated, in a way that could be otherwise attained only after a tedious and difficult dissection. Moreover, by injecting the bloodvessels with a preparation of red lead, the radiogram might be made to reveal the state of the fœtal circulation.

When medico-legal evidence is required of the viability of a fœtus, however, the Röntgen photograph is only, as a rule, of corroborative value, inasmuch as it reveals the full-term bony development or otherwise. It is never likely to supersede in any way the evidence now tendered and accepted as to live birth, such as, for instance, the hydrostatic lung test. Viability, it should be remembered, is possible at seven months. The material things that may be readily demonstrated in court by means of a radiogram are fractures of the skull and other parts of the body, and the appearance of the osseous nucleus of the inferior femoral epiphysis, to which Husband, in his 'Forensic Medicine,' as a result of the examination of nine intra-uterine fœtuses at the ninth month, ascribes a maximum length of 2 lines. The subject of fœtal ossification is an interesting one, and no doubt the conclusions now laid down by anatomists will, sooner or later, be widely tested by the convenient Röntgen methods.

Positive *x*-ray evidence, however, as to the fact of separate existence of a child has been suggested by M. Bordas.* On June 8, 1896, he laid before the Paris Société de Médecine Légale two Röntgen photographs of fœtal lungs which showed the presence of air-bubbles in those who had breathed, as against absolute opacity in the still-born.

V. EVIDENCE OF DEATH

It has been proposed to apply the rays as a test of death, on the assumption that there would be increased resistance on the part of dead tissues; but it has not been found possible to carry out the suggestion in that way. The desired test, however, has been found in another direction, namely, by taking an *x*-ray observation of the heart. During life the pulsating upper cardiac margin, as seen from the back, throws a diffuse shadow on screen or negative, whereas the non-pulsating dead heart yields a sharp record, both fluoroscopic and photographic. In this way an important yet simple addition has been made to the trustworthy signs of death; and the discovery of Röntgen should thus bring comfort to those whose minds are possessed of the time-worn fables of premature burial.

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* 'Technique des Rayons X,' A. Hébert, Paris, 1897, p. 105.

VI. EVIDENCE IN ACTION FOR MALPRAXIS

The Röntgen rays may prove of great value to the protection of medical men, when otherwise it might be difficult to meet a charge of negligence. This point is put in a nutshell by Dr. Richardson,* of Boston, who writes: 'Indeed, an early fluoroscopic examination of every fracture may be required of every surgeon for the protection of the patient, and an early photograph for the protection of the surgeon.' At the beginning of the same year Mr. Howard Marsh advanced the statement: 'From a medico-legal point of view the Röntgen photography will clearly play a leading part in cases where surgeons are charged with having overlooked a fracture or a dislocation, when no such injury is present.'

In one instance the present writer was called upon to make a Röntgen ray examination in an action brought against a medical man for negligence in overlooking a broken rib or ribs. The plaintiff, an elderly, stout, asthmatic man, had been thrown out of a vehicle, and fell lengthwise, with his right nipple line along the edge of the kerbstone. As the alleged injury was in front of the body and over the site of the liver, it was found impossible to photograph the ribs in that position, although the writer has since succeeded in getting a perfect picture of the front ends of the lower ribs in a living adult man of average build. Although the result proved negative, so far as the plaintiff's ribs were concerned, it nevertheless revealed the fact that he was suffering from aneurism and from bronchiectatic cavities of the lung. The existence of the aneurism, by the way, was denied by the plaintiff's physician, but it should be noted that in so large a chest it would have been well-nigh impossible to discover, under the particular circumstances, the aneurism by any means other than the rays. The plaintiff failed to bring any positive evidence as to the alleged fracture, and his case broke down after the examination of the defendant.

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* *Boston Medical News*, December 19, 1896.

As regards one branch of irregular or quack medical practice the x-ray photography is likely to do yeoman's service. The bone-setters are a fraternity who batten on the ignorance and the credulity of their victims. Their almost invariable plan is to tell the sufferer that a 'bone is out,' or is 'broken,' or 'has not been properly set.' In all these conditions the Röntgen rays may be trusted to reveal the truth or otherwise of the assertion. Hence it will be wise in future for everyone who consults a member of that fraternity to verify the resulting diagnosis by an appeal to the rays before he submits to any manipulations. There is one form of fixed joint after injury, due to fibrous adhesions between the articular surfaces. In such a case the bone-setter declares the joint is dislocated, and breaks down the adhesions by a sudden wrench. Now, in such a fixation the Röntgen examination shows the absence of dislocation. On the other hand, if a clear space indicates a joint not filled with osseous or other opaque matter (fibrous bands being transparent), then the immobility of the joint may safely be ascribed to fibrous anchylosis. Several cases of this kind, based on the negative evidence of a clear tracing of the joint space, and the positive evidence of a normal relation of bones of a fixed joint and of a previous injury, are given in the section upon 'Bones' (see p. 131).

Mr. Howard Marsh has observed of the method: 'It would have furnished valuable information to a patient met with some years ago, who had slight lateral curvature of the spine. This patient was told by a bone-setter that "his pelvis had opened, and both his hips were out." The reassurance and the mental calm which a Röntgen photograph could now bring to anyone who, having nothing seriously wrong, had been told he was the subject of such a formidable condition of things, can be easily imagined.'

It may be hoped, then, that the Röntgen rays will help to rid the world of this class of harmful social parasites. Sooner or later the strong hand of Science must infallibly cut the ground away from under the feet of all such pretenders.

HINTS IN PREPARING EVIDENCE

In seeking Röntgen ray evidence, it is clear that the wisest course will be for the lawyer to go at once to a skilled medical operator. There is no process that needs more accurate general and special knowledge than that involved in preparing *x*-ray medical evidence. Pitfalls await the unwary or the non-medical witness on every hand, as he and his principals may find to their cost on his appearance in the witness-box. The following hints may possibly be of some service to those who are called upon to furnish legal evidence of the kind:

Make a note of patient and of his case, with full details, such as name, address, date, history, and symptoms. If possible, make the examination in the presence of the medical man or men engaged on the opposite side. All notes to be reduced to writing at the earliest opportunity.

Never neglect to make a screen as well as a photographic examination.

Make an identifying mark (to be entered in notes) on all photographic plates. Keep all negatives and photographs under lock and key, and under no circumstances allow the originals to leave your possession. Neglect of this precaution may lose a suit.

Remember that the Röntgen method reveals mainly injuries to bone, whereas soft-tissue damage may be quite as disabling to the patient.

Be careful to guard against fallacies such as those due to position of parts in relation to the tube. This can be done by having comparative photographs of the corresponding sound parts; indeed, that should be the invariable rule in legal cases. Wherever possible, make an exact localization.

Sometimes firm union occurs in a fracture, although the Röntgen photograph may not register bony union for many months afterwards.

An ununited epiphysis may be mistaken for a fracture, or the injury disclosed may be one of old standing.

Negative evidence, *e.g.*, the absence of a bullet, is often as valuable as positive.

Think out all the points of the case, and make no statement which you cannot justify in the witness-box. Carefully sift out matters of fact from matters of opinion.

It is well to have an understanding as to the amount of fee to be tendered for expert evidence before attending court. In one case brought to the attention of the writer, a medical operator was appealed to *ad misericordiam* to accept a nominal fee in an action brought against a brother professional; the latter won the day, and costs fell upon the other side, but no increase was made in the sum first agreed upon.

G. ANATOMY

A GOOD deal of light has been already acquired in relation to the age at which union of bony epiphyses takes place. It seems likely, in view of the facts afforded by Röntgen ray researches, that much of the information upon this point contained in the anatomical text-books will have to be rewritten. It appears certain, for instance, that the variation of the individual in this matter is much wider than hitherto recognised by the anatomists. The new method offers obvious advantages in obtaining data for general conclusions as to ages of ossific union. Supposing, for instance, it be desired to study the epiphyses of the humerus at the age of fourteen. A sufficient number of Röntgen photographs of the humerus of persons of that age—carefully verified, it need hardly be said—would have to be procured, and the results compared at leisure. This method would be rapid and accurate as compared with the tedious and more or less uncertain observations to be gleaned from the alternative plan of many laborious dissections. Moreover, the rays could be applied to the living as well as to the dead, and also to bodies where post-mortem examination would be impossible.

The most authoritative tables yet drawn up on this subject are those of Mr. Poland, quoted on page 152.

ANATOMY OF BLOODVESSELS

The injection of bloodvessels by some material opaque to the rays, and then subjecting them to the new method, opens up a wide field of anatomical investigation. In this way Dr. F. J. Clendinnen, of Melbourne,* demonstrated the arteries of a seven-months fœtus, which he had injected with a solution of red lead. That particular salt was used because, as the result of previous experiments, he had come to the conclusion that red was more opaque than other colours. His record afforded a sharp and beautiful diagrammatic view of the arteries, even where they passed behind the fœtal bones. A peculiarity such as that of double high division of the brachial artery was well shown.

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* *International Medical Journal of Australasia*, October 20, 1896, p. 611.

In a later issue of the same journal (January 20, 1897), Dr. Clendinnen published some further illustrations obtained in a similar way. They showed the arteries about the knee and the ankle-joint. The small muscular twigs and other minute branches were reproduced with the utmost fidelity.

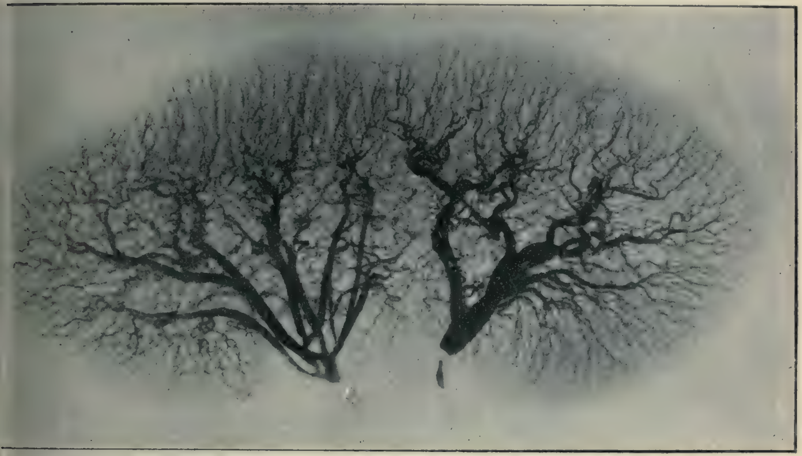

FIG. 96.—INJECTED BLOODVESSELS OF HUMAN KIDNEY.

By Dawson Turner.

There can be no doubt that this method may now and then afford a valuable means of showing in a graphic manner the facts of local blood-supply, both in normal and in pathological specimens. As an instance of the latter, a perfect picture could be obtained of circulation by anastomoses, say, in a case where during life the femoral artery had been tied for aneurism, or in the stump of an amputated limb.

Dr. Clendinnen adds that in one case he obtained from the living body a good record of the popliteal artery. This observavation is valuable, and perhaps points to the time when a fuller knowledge of conditions in relation to results will bring the bloodvessels under command of the Röntgen ray worker.

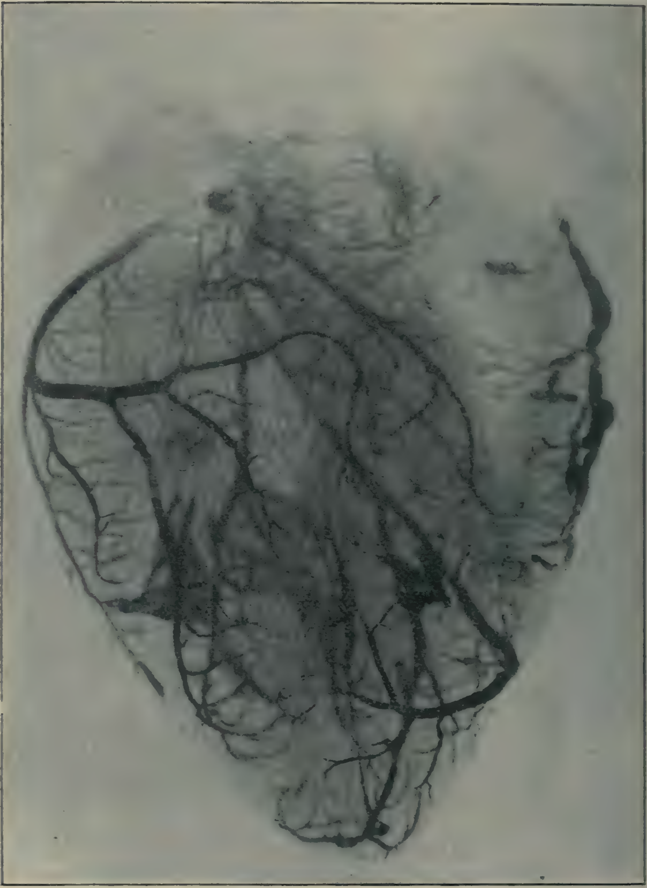

FIG. 97.—INJECTED BLOODVESSELS OF HUMAN HEART.
By Dawson Turner.

Messrs. Rémy and Contremoulins have made similar observa tions by injecting the arteries with a solution of wax in alcoho charged with various metallic powders.

Dr. Nathan Raw showed to the Manchester Pathologica

Society, in December, 1896, Röntgen photographs of arteries injected with plaster of Paris and carmine.

Another application of this principle of opaque injection was brought forward by Poncet, of Lyons.* He presented the Academy of the town mentioned with a series by Destot and Bérard, showing the arterial and venous circulation of the kidney in various pathological conditions of that organ.

Some of the interesting conclusions as to normal vascular supply may be quoted. Thus, it was found that the circulation in the kidney is lobar and terminal, and permits the differentiation of an independent anterior and posterior kidney, except the artery of the superior lobe, which often divides into two branches, so that, when it is injected, the entire upper portion is permeated. Professor Dawson Turner has kindly allowed a reproduction of photographs of an injected human kidney and heart (Figs. 96 and 97), prepared by the slow injection of an ordinary dissecting-room preparation made rather thin.

Some beautiful and instructive views of the circulation in internal organs, such as the brain or the liver, may be obtained by stereoscopy.

The bearing of researches of this nature upon the study of the evolution of organs is obvious.

Another field in normal anatomy is the relation of parts in the various internal regions of the body. The exact relation of the bladder and urethra, for instance, might be studied by filling the organ and passages with melted paraffin, holding in solution some opaque mineral substance, as zinc or lead oxide.

In pathological anatomy, it is possible that not a few points of interest might be solved by injecting the hollow viscera with opaque solutions, and then taking a radiogram of the result.

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* *Gazette des Hôpitaux*, December 31, 1896.

H. PHYSIOLOGY

INTERESTING results have been obtained by Messrs. Hébert and Bertin-Sans from the study on the screen of the movements of joints, more especially in the case of the wrists. The observations will no doubt be sooner or later considerably extended.

A number of interesting observations have already been made upon the movements of the heart, and also upon the varying relationship between the pulsating heart and the diaphragm.

M. Bouchard* has reported marked dilatation of the auricle when the intra-thoracic blood-pressure was raised during inspiration. The same condition could be artificially brought about by endeavouring to inspire with the glottis shut, and occurred naturally during the violent inspirations of a paroxysm of whooping cough. He also noted a clear space between the heart and diaphragm during forced, but not during ordinary inspiration.

Schott† found it easy to cause transient dilatation of the heart by hard muscular exercise.

Wherever in the interior of the body there is pulsation in any organ open to the x-rays, the process of chrono-photography will be available. The possible presentation of a pulsating human heart upon a lantern screen, by a method so young that it is yet barely articulate, speaks volumes for the energy of latter-day science.

Dr. Macintyre has produced cinematographic views of the human body. This branch of the subject is likely to be greatly advanced when it is possible to take flash exposures of deep adult structures.

Professor Benedikt, of Vienna, has found that movements of the heart are best studied in young or emaciated subjects. He noted during cardiac systole a shortening between apex and base, and concluded there was only a systolic lateral apex impulse. Further, during systole the heart is not entirely emptied of blood, for a shadow cast by residual blood is recognisable. The bloodless heart is relatively transparent, but even thin layers of blood cast a shadow. These observations certainly seem to upset Skoda's teaching, that the apex beat is due to the resistance of the blood.

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* *Lancet*, September 10, 1898.

† *Deutsch. Med. Wochen.*, vol. xxviii., p. 495, 1897.

One of the most interesting investigations in physiological movements has been made on the fluorescent screen by Scheir, of Berlin, who reported his results to the Congress of Medicine in August, 1897. If the rays passed through the head laterally, the naso-pharyngeal space and upper part of the pharynx were seen as clear shadows, and if the person under examination uttered a vowel sound, the velum was seen to be raised and to take up a position in the naso-pharyngeal space, varying according to the nature of the sound. With the vowel *a*, the velum was raised the least, and was successively raised more and more by the succeeding vowels *e*, *o*, *u*, *i*. The velum was more raised in high than in low tones. The form of the mouth in the pronunciation of the different consonants could also be plainly seen. The shape and position of the tongue, the lips, and the jaws could also be distinguished. The rays clearly showed the movements of the larynx, velum, and other parts in swallowing, breathing, and sneezing, and in pathological conditions the irregularities could be determined with precision.*

Messrs. Sabrazès and Rivière in 1897 announced to the Paris Academy of Science that the rays had no influence either upon the action of white blood corpuscles, or upon the phenomena of phagocytosis, while a frog's heart exposed to the rays for several hours appeared to undergo no alteration of movement.†

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* *Medical Press and Circular*, September 1, 1897, p. 212.

† *Lancet*, May 29, 1897, p. 1505.

I. THE RAYS IN VETERINARY SURGERY.*

A GOOD deal of work has been done with the Röntgen rays in veterinary practice by Professor Hobday and others.†

The horse's hoof he found to be readily penetrable by the rays, so that a foreign metallic body, such as a misdirected nail, could be at once detected in that region, and he obtained excellent radiograms of dogs and cats suffering from various accidents. In the *Veterinarian* for September, 1896, Professor Hobday and Mr. Johnson wrote: 'In conclusion, the authors consider that the Röntgen rays can be successfully applied to the smaller animals without much difficulty. In the horse, the mechanical difficulties of restraint have been successfully overcome. . . . For diagnosis of abnormalities of the bones of the limbs, such as suspected fracture of the pastern, small ringbone, sidebone, or foreign body in the hoof, the results demonstrate that this method can be applied successfully. With the bones of the neck, too, no great difficulty is anticipated.'

Since that time further work has been done by Major Frederick Smith, of the Army Veterinary Department, and Professor Hobday, the results being to effect a great reduction of exposure and to bring the method within more practical limits, also to show the value of the screen in certain cases.

The main difficulties have arisen in connection with the diagnoses of spavin and navicular disease. In spavin the closeness of the bones to each other, their curved articular surfaces, the presence of overhanging ridges so frequently found in normal hocks, together with the fact that the bones are placed one behind the other, made the task of unusual difficulty.

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* This section has been kindly revised by Professor F. Hobday, of the Royal Veterinary College, London.

† *Journal of Comparative Pathology and Therapeutics*, vol. ix., p. 58 ; *Veterinary Record*, September, 1896.

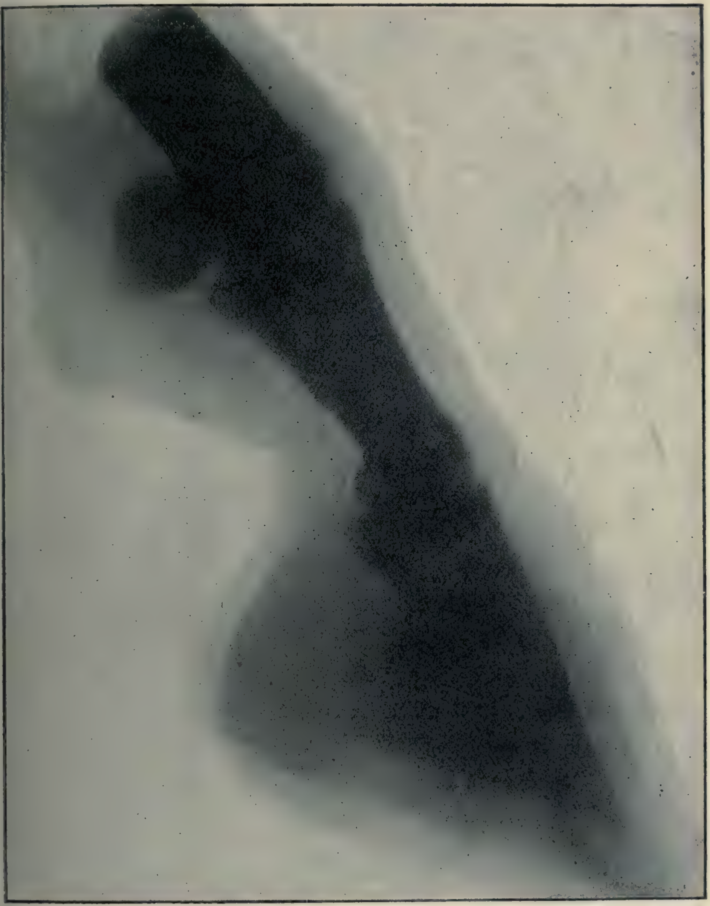

FIG. 98.—PHALANGES OF HORSE'S HOOF (60 seconds' exposure). By A. W. Isenthal.

In navicular disease the experimenters have up to the present had to acknowledge failure, as the position of the bone in regard to its surroundings and the nature of the lesion render attempts to further diagnosis by the application of the x-rays abortive.

APPENDIX

A NEW FORM OF RADIATION

BEING A PRELIMINARY COMMUNICATION TO THE WÜRZBURG PHYSICO-MEDICAL SOCIETY, BY PROFESSOR WILHELM KONRAD RÖNTGEN, DECEMBER, 1895.

1. If we pass the discharge from a large Ruhmkorff coil through a Hittorf or a sufficiently exhausted Lenard, Crookes, or similar apparatus, and cover the tube with a somewhat closely-fitting mantle of thin black cardboard, we observe in a completely-darkened room that a paper screen washed with a barium-platino-cyanide lights up brilliantly and fluoresces equally well whether the treated side or the other be turned towards the discharge-tube. Fluorescence is still observable 2 metres away from the apparatus. It is easy to convince one's self that the cause of the fluorescence is the discharge from the apparatus, and nothing else.

2. The most striking feature of this phenomenon is that an influence capable of exciting brilliant fluorescence is able to pass through the black cardboard cover, which transmits none of the ultra-violet rays of the sun or of the electric arc, and one immediately inquires whether other bodies possess this property. It is soon discovered that all bodies are transparent to this influence, but in very different degrees. A few examples will suffice. Paper is very transparent;[*] the fluorescent screen still lighted up brightly when held behind a bound volume of 1,000 pages; the printer's ink offered no perceptible obstacle. Fluorescence was also noted behind two packs of cards; a few cards held between tube and screen made no perceptible difference. A single sheet of tinfoil is scarcely noticeable; only after several layers have been laid on top of each other is a shadow clearly visible on the screen. Thick blocks of wood are also transparent; fir-planks from 2 cm. to 3 cm. thick are but slightly opaque. A film of aluminium about 15 mm. thick weakens the effect considerably, though it does not entirely destroy the fluorescence. Several centimetres of vulcanized indiarubber let the rays through.[†] Glass plates of the same

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[*] By the 'transparency' of a body I denote the ratio of the brightness of a fluorescent screen held right behind the body in question to the brightness of the same screen under exactly the same conditions, but without the interposing body.

[†] For brevity's sake I should like to use the expression 'rays,' and to distinguish these from other rays I will call them 'x-rays'

thickness behave in a different way, according as they contain lead (flint glass) or not; the former are much less transparent than the latter. If the hand be held between the tube and the screen, the dark shadow of the bones is visible within the slightly dark shadow of the hand. Water, bisulphide of carbon, and various other liquids behave in this respect as if they were transparent. I was not able to determine whether water was more transparent than air. Behind plates of copper, silver, lead, gold, platinum, fluorescence is still clearly visible, but only when the plates are not too thick. Platinum 0·2 mm. thick is transparent; silver and copper sheets may be decidedly thicker. Lead 1·5 mm. thick is practically opaque, and was on this account often made use of. A wooden rod of 20 by 20 mm. cross-section, painted with white lead paint on one side, behaves in a peculiar manner. When it is interposed between apparatus and screen it has almost no effect when the x-rays go through the rod parallel to the painted side, but it throws a dark shadow if the rays have to traverse the paint. Very similar to the metals themselves are their salts, whether solid or in solution.

3. These and other experimental results led to the conclusion that the transparency of different substances of the same thickness is mainly conditioned by their density; no other property is in the least comparable with this.

The following experiments, however, show that density is not altogether alone in its influence. I experimented on the transparency of nearly the same thickness of glass, aluminium, calcspar, and quartz. The density of these substances is nearly the same, and yet it was quite evident that the spar was decidedly less transparent than the other bodies, which were very much like each other in their behaviour. I have not observed calcspar fluoresce in a manner comparable with glass.

4. With increasing thickness all bodies become less transparent. In order to find a law connecting transparency with thickness, I made some photographic observations, the photographic plate being partly covered with an increasing number of sheets of tinfoil. Photometric measurements will be undertaken when I am in possession of a suitable photometer.

5. Sheets of platinum, lead, zinc, and aluminium were rolled until they appeared to be of almost equal transparency. The following table gives the thicknesses in millimetres, the thicknesses relative to the platinum sheet, and the density:

Thickness.	*Relative Thickness.*	*Density.*
Pt 0·018	1	21·5
Pb 0·05	3	11·3
Zn 0·10	6	7·1
Al 3·5	200	2·6

It is to be observed in connection with these figures that, although the product of the thickness into the density may be the same, it does not in any way follow that the transparency of the different metals is the same. The transparency increases at a greater rate than this product decreases.

6. The fluorescence of barium-platino-cyanide is not the only recognisable phenomenon due to x-rays. It may be observed, first of all, that other bodies fluoresce—for example, phosphorus, calcium compounds, uranium glass, ordinary glass, calcspar, rock salt, etc.

Of especial interest in many ways is the fact that photographic dry plates show themselves susceptible to x-rays. We are thus in a position to corroborate many phenomena in which mistakes are easy, and I have, whenever possible, controlled each important ocular observation on fluorescence by means of photography. Owing to the property possessed by the rays of passing almost without any absorption through thin sheets of wood, paper, or tinfoil, we can take the impressions on the photographic plate inside the camera or paper cover whilst in a well-lit room. In former days this property of the ray only showed itself in the necessity under which we lay of not keeping undeveloped plates, wrapped in the usual paper and board, for any length of time in the vicinity of discharge-tubes. It is still open to question whether the chemical effect on the silver salts of photographic plates is exercised directly by the x-rays. It is possible that this effect is due to the fluorescent light which, as mentioned above, may be generated on the glass plate, or perhaps on the layer of gelatine. 'Films' may be used just as well as glass plates.

I have not as yet experimentally proved that the x-rays are able to cause thermal effects, but we may very well take their existence as probable, since it is proved that the fluorescent phenomenon alters the properties of x-rays, and it is certain that all the incident x-rays do not leave the bodies as such.

The retina of the eye is not susceptible to these rays. An eye brought close up to the discharge apparatus perceives nothing, although, according to experiments made, the media contained in the eye are fairly transparent.

7. As soon as I had determined the transparency of different substances of various thicknesses, I hastened to ascertain how the x-rays behaved when passing through a prism—whether they were refracted or no. Water and carbon disulphide, in prisms of about 30° refractive angle, showed neither with the fluorescing screen nor with the photographic plate any sign of refraction. For purposes of comparison the refraction of light rays was observed under the same conditions; the refracted images on the plate were respectively about 10 mm. and 20 mm. from the non-refracted one. With an aluminium and a vulcanized rubber prism of 30° angle I have obtained images on photographic plates in which one may perhaps see refraction. But the matter is very uncertain, and even if refraction exists, it is so small that the refractive index of the x-ray for the above materials can only be, at the highest, 1·05. Using the fluorescent screen, I was unable to discover any refraction at all in the case of the aluminium and the rubber prism.

Researches with prisms of denser metals have yielded up to now no certain results, on account of the small transparency, and consequently lessened intensity, of the transmitted ray.

In view of this state of things, and the importance of the question whether x-rays are refracted on passing from one medium to another, it is satisfactory to find that this question can be attacked in another way than by means of prisms. Finely-powdered substances in sufficient thicknesses allow only a very little of the incident light to pass through, and that is dispersed by refraction and reflection. Now, powdered substances are quite as transparent to x-rays as are solid bodies of equal mass. Hence, it is proved that refraction and regular reflection do not exist to a noticeable degree. The experiments were carried out with finely-powdered rock salt, with powdered electrolytic silver, and with the zinc powder much used in chemical work. In no case was any difference observed between the transparency of the powdered and solid substance, either when using the fluorescent screen or the photographic plate.

It follows, from what has been said, that the x-rays cannot be concentrated by lenses ; a large vulcanized rubber and glass lens were without influence. The shadow of a round rod is darker in the middle than at the edge ; that of a tube filled with any substance more transparent than the material of the tube is lighter in the middle than at the edge.

8. The question of the reflection of the x-rays is settled in one's mind by the preceding paragraphs, and no appreciable regular reflection of the rays from the substances experimented with need be looked for. Other investigations, which I will describe here, lead to the same result. Nevertheless, an observation must be mentioned which at first sight appears to contradict the above statement. I exposed a photographic plate to the x-rays, protected against light rays by black paper, the glass side being directed towards the discharge-tube. The sensitive layer was nearly covered, star fashion, with blanks of platinum, lead, zinc, and aluminium. On developing the negative, it was clearly noticeable that the blackening under the platinum, lead, and especially under the zinc, was greater than in other places. The aluminium had exercised hardly any effect. It appeared, therefore, that the three above-mentioned metals had reflected the rays. Nevertheless, other causes for the greater blackening were thinkable, and in order to make sure I made a second experiment, and laid a piece of thin aluminium, which is opaque to ultra-violet rays, though very transparent to x-rays, between the sensitive layers and the metal blanks. As again much the same result was found, a reflection of x-rays by the above-mentioned metals was demonstrated. But if we connect these facts with the observation that powders are quite as transparent as solid bodies, and that, moreover, bodies with rough surfaces are, in regard to the transmission of x-rays, as well as in the experiment just described, the same as polished bodies, one comes to the conclusion that regular reflection, as already stated, does not exist, but that the bodies behaved to the x-rays as muddy media do to light.

Again, as I could discover no refraction at the point of passage from one medium to another, it would seem as if the x-rays went through all substances at the same speed, and that in a medium which is everywhere, and in which the material particles are embedded, the particles obstruct the propagation of the x-rays in proportion to the density of the bodies.

9. Hence it may be that the arrangement of the particles in the bodies influences the transparency ; that, for example, equal thicknesses of calcspar would exhibit different transparencies, according as the rays were in the direction of the axis or at right angles to it. Researches with calcspar and quartz have yielded a negative result.

10. It is well known that Lenard, in his beautiful investigation on Hittorf cathode rays passed through thin aluminium-foil, came to the conclusion that these rays were actions in the ether, and that they pass diffusively through all bodies. I have been able to say the same about my rays.

In his last work Lenard has determined the absorption coefficient of various bodies for cathode rays, and among other things for air atmospheric pressure at 4·1, 3·4, 3·1, per centimetre, and found it connected with the exhaustion of the gas contained in the discharge apparatus. In order to estimate the discharge pressure by the spark-gap method, I used in my researches almost always the same exhaustion. I succeeded with a Weber photometer (I do not possess a better one) in comparing the intensity of the light of my fluorescing screen at distances of about 100 mm. and 200 mm. from the discharge apparatus, and found in the case of three tests agreeing well with one another, that it varied very nearly inversely as the square of the distance of the screen from the discharge apparatus. Hence the air absorbs a very much smaller fraction of the x-rays than of the cathode rays. This result is also quite in agreement with the result previously mentioned, that the fluorescing light was still observable at a distance of 2 metres from the discharge-tube.

Other bodies behave generally like air—that is to say, they are more transparent for x-rays than for cathode rays.

11. A further noteworthy difference in the behaviour of cathode rays and x-rays consists in the fact that, in spite of many attempts, I have not succeeded, even with very strong magnetic fields, in deflecting x-rays by a magnet. The magnetic deflection has been, up to now, a characteristic mark of the cathode ray ; it was, indeed, noticed by Hertz and Lenard that there were different kinds of cathode rays, 'distinguishable from one another by their phosphorescing powers, absorption and magnetic deflection,' but a considerable deflection was nevertheless observed in all cases, and I do not think this characteristic will be given up without overwhelming evidence.

12. After experiments bearing specially on this question, it is certain that the spot on the wall of the discharge apparatus which fluoresces most decidedly must be regarded as the principal point of the radiation of the x-rays in all directions. The x-rays thus start from the point at which, according to the researches of different investigators, the cathode rays impinge upon the wall of the glass tube. If one deflects the cathode rays

within the apparatus by a magnet, it is found that the x-rays are emitted from another spot—that is to say, from the new termination of the cathode stream.

On this account, also, the x-rays, which are not deflected, cannot merely be unaltered reflected cathode rays passing through the glass wall. The greater density of the glass outside the discharge-tube cannot, according to Lenard, be made responsible for the great difference in the 'deflectability.'

I therefore come to the conclusion that the x-rays are not identical with the cathode rays, but that they are generated by the cathode rays at the glass wall of the discharge apparatus.

13. This excitation does not take place only in glass, but also in aluminium, as I was able to ascertain with an apparatus closed by a sheet of aluminium 2 mm. thick. Other substances will be studied later on.

14. The justification for giving the name of 'rays' to the influence emanating from the wall of the discharge apparatus depends partly on the very regular shadows which they form when one interposes more or less transparent bodies between the apparatus and the fluorescing screen or photographic plate. Many such shadow-pictures, the formation of which possesses a special charm, I have observed—some photographically. For example, I possess photographs of the shadow of the profile of the door separating the room in which was the discharge apparatus from the room in which was the photographic plate; also photographs of the shadows of the bones of the hand, of the shadow of a wire wound on a wooden spool, of a weight enclosed in a small box, of a compass in which the magnetic needle is completely surrounded by metal, of a piece of metal the lack of homogeneity of which was brought out by the x-rays, etc.

To show the rectilinear propagation of the x-rays there is a pinhole photograph, which I was able to take by means of the discharge apparatus covered with black paper. The image is weak, but unmistakably correct.

15. I looked very carefully for interference phenomena with x-rays, but unfortunately, perhaps on account of the small intensity of the rays, without success.

16. Researches to determine whether electrostatic forces affect x-rays in any way have been begun, but are not completed.

17. If we ask what x-rays—which certainly cannot be cathode rays—really are, we are led at first sight, owing to their powerful fluorescing and chemical properties, to think of ultra-violet light. But we immediately encounter serious objections. If x-rays be in reality ultra-viole light, this light must possess the following characteristics:

(*a*) It must show no perceptible refraction on passing from air int water, bisulphide of carbon, aluminium, rock salt, glass, zinc, etc

(*b*) It must not be regularly reflected to any appreciable extent from the above bodies.

(*c*) It must not be polarizable by the usual means.

(*d*) Its absorption must not be influenced by any of the properties of substances to the same extent as it is by their density.

In other words, we must assume that these ultra-violet rays behave in quite a different manner from any infra-red, visible, or ultra-violet rays hitherto known. I could not bring myself to this conclusion, and I have, therefore, sought another explanation.

There seems at least some connection between the new rays and light rays in the shadow-pictures and in the fluorescing and chemical activity of both kinds of rays. Now, it has long been known that, besides the transverse light vibrations, longitudinal vibrations might take place in the ether, and, according to the view of different physicists, must take place. Certainly their existence has not up till now been made evident, and their properties have not, on that account, been experimentally investigated.

May not the new rays be due to longitudinal vibrations in the ether?

I must admit that I have put more and more faith in this idea in the course of my research, and I therefore advance that surmise, although I know that such an explanation requires further corroboration.

APPENDIX II.: MEDICAL AND SURGICAL

ANATOMY

Blake* studied the relation of the trachea and bronchi to the thoracic walls in the cadaver. He hardened with formalin, and injected a metallic alloy into the trachea and bronchi, which he then examined with the rays. He concluded that the trachea lies in the right sternal line at its bifurcation, a point that corresponds with the right side of the intervertebral disc between the fourth and fifth dorsal vertebræ. The point, however, is influenced both by respiratory movements and by the position of head and neck: in front it is just internal to the junction of the lower border of the second costal cartilage with the sternum in adults, and under the right border of the sternum at the level of the third costal cartilage in children.

In the first volume of a beautifully-illustrated Röntgen ray atlas of normal and pathological anatomy,† Professor Lambertz gives a detailed account of the ossification of the skeleton from its earliest appearance in the embryo up to the period of birth. There are many admirable illustrations.

The second part deals with the upper extremity. It gives many interesting examples of congenital defects, such as fœtal amputations, brachydactylism, hyperphalanxism, and polydactylism.

Bloodvessels

At a meeting of the Biological Society of Paris, June 11, 1898, M. Turbert ‡ showed two radiograms, the first of which, taken from a dead body, showed clearly the radial and ulnar arteries; and the course of these arteries could be followed even where their radiographic shadow was superimposed upon that of the bone. The vessels had not been injected in that case nor in the second, which showed the interior tibial artery for the greater part of its course in the foot of an old man.

An extensive series of investigations has been made by Mr. W. Smith §

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* *American Journal of Medical Sciences*, March, 1899.

† 'Atlas der normalen und pathologischen Anatomie in typischen Röntgenbildern.' Hamburg: Gräfe und Sillem, 1900.

‡ *Lancet*, June 25, 1898, p. 1788.

§ *American X-Ray Journal*, December, 1898.

upon arteries injected with vermilion. One of an amputation at the lower end of the thigh shows well the reduction of the trunk of the femoral artery to a slender vessel.

An extremely good radiogram of a five-day-old infant injected with liquid mercury has been published by Dr. A. V. L. Brokan, of St. Louis.* 'To the anatomist,' he writes, 'the study of injected vessels is particularly interesting, the relationship to the osseous system showing far better than some dissections.'

Brain

The topographical relations of the brain, the frontal and maxillary sinuses, and the venous sinuses of the dura mater to the walls of the skull have been studied by Drs. Paul Regnier and Jules Glover. A translation of their article on the subject will be found in the *Lancet.*†

They can hardly be said to have made any new observations, but they confirm and bring out various points in an interesting manner. It may be noted that, for their anatomical preparations, they used sections of the heads of young subjects in whom the cranial sutures were not yet anchylosed. In order to preserve as far as possible the exact relations of the brain to the skull, the specimen was injected with formol through the carotid artery. This was repeated two or three times at intervals of one or two days, so as to harden the brain *in situ* without appreciably changing its shape or size. An antero-posterior section was mad some weeks later through skull and brain. The cerebral hemisphere wa then taken out, and the pia mater removed, as the presence of tha membrane prevents a sharp record of the convolutions upon the sensitiv plate. Injections of the venous sinuses were made with bronze powde held in suspension either in a solution of wax or else in tallow. Th distance of the tube from the plate was always 45 centimetres (18 inches and exposure varied from ten to forty minutes. The results of thes investigations were reported to the Paris Academy of Medicine, August 1 1897. Illustrative radiograms are printed in the *Journal des Practicie* of September 4, 1897, and in *La Radiographie.* The authors a careful to point out that allowance must be made for distortions.

Their main conclusions are that it is possible to superpose upon th photographic plate the outline of the cranial sutures and of the cerebr fissures and convolutions. The outlines of the lateral ventricle can traced. The relations of the venous sinuses, especially of the lateral sinu to the skull can be defined both in the child and in the adult. Th extremely variable form of the cavities and bony cells of the bony sinus can be studied. The exact position of the three levels of the base of t skull can also be ascertained with regard to the outer skull. The opaq triangular base of implantation of the petrous on the squamous portion the temporal bone can be demonstrated. The authors corroborate the observation that in some cases the lateral sinus corresponded with the anterior, the centre, or the posterior part of the mastoid. They mention a clear patch seen by the fluorescent screen normally in the head of young infants, and corresponding with the median portion of the brain. They say that this normal transparency is certainly more perceptible in the pathological state when the ventricle is dilated with fluid.

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* *American X-Ray Journal,* August, 1898, p. 358.

† *Lancet,* February 24, 1900, p. 525.

SURGERY

Excision of Semilunar Cartilage

Mr. F. D. Bird has published a case of a boy from whose knee-joint he had removed the internal semilunar cartilage; the boy previously had been almost entirely crippled from the condition of the joint with its accompanying attacks of synovitis. After the operation the action of the knee-joint became perfect, and the boy could not only follow his occupation, but even play football.*

Cervical Rib: Operation

An interesting case has been recorded by T. E. Gordon, M.B., Surgeon to the Adelaide Hospital, of obliteration of the arteries of the right arm and partial gangrene of fingers due to a cervical rib. A cervical rib on either side was disclosed by the radiogram, that on the right being the higher and more horizontal. Excision of this right rib relieved the condition. The author classifies cases of cervical ribs under three headings: '(1) Where no symptoms are produced, and this is the largest class; (2) where the rib gives rise to nervous symptoms only, such as wasting and loss of power, pain, and chilliness; (3) where the leading symptoms are circulatory.' Of the last-mentioned rare condition the author collected seven cases.

Deformities

The 'Small' Chinese Foot

Two radiograms showing the deformity of a Chinese lady's foot, with a good note of the condition, have been published by Dr. J. Duncan Thomson,† of Hankow, China. Speaking of the illustrations, he writes:

> 'The first is that of a small foot, taken with the inner (tibial) side next the plate; the second is that of a small foot, taken with the outer (fibular) side next the plate. The deformity is caused, on the one hand, by bending the arch of the foot so as to bring its ends (the heel and the balls of the toes) together; and, on the other hand, by bending the four outer toes under the first or big toe.

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* For radiogram (taken by Dr. Clendinnen), see *Intercolonial Medical Journal of Australasia*, July 20, 1900.

† *British Medical Journal*, June 8, 1901, p. 1395.

> Compare now the skiagraphs, and it will be seen that the former procedure is to cause the joints on each side of the navicular bone to gape, to wedge up the cuboid, to overflex the ankle-joint, bringing the astragalus to lie almost at right angles to the leg bones, and the calcaneum to point downwards and backwards (in place of slightly upwards and backwards), and to bring the cuneiforms and metatarsals to point downwards almost parallel to the big bones. As this is begun during infancy, the development of the bones is arrested, notably that of the metatarsals, the cuboid, and the anterior end of the calcaneum. This arrest in development extends further to the bones and to the muscles of the leg. In those who take exercise the thighs are usually well developed. Owing to the difficulty in taking healthy exercise, however, it may be seen that in the majority the whole system may suffer, and that after many generations the race as a whole may be adversely affected, both physically and morally.'

Dr. Carl Beck[*] read an interesting paper on congenital osseous malformations before the Diseases of Children Section at the annual meeting of the American Medical Association, 1901. Among other cases, he described one of a boy of five, in whom the rays showed one phalanx in the thumb and two phalanges each in the fingers. Operation secured a fairly good thumb. The same child had congenital fracture of radius and ulna in the lower third; the bones were wired, and perfect union was obtained. There was, furthermore, congenital constriction at the region of the surgical neck of the humerus, where a deep furrow encircled the whole circumference of the arm. Palpation detected no soft tissues between the integument and the bone; an exploratory incision revealed fragments of the biceps, triceps, and deltoid muscles, the edges of which were refreshed and united with catgut. A fair result was obtained fourteen months after operation. Another case showed congenital absence of the metatarsal and corresponding phalanges; another, congenital absence o nasal bones and arrested development of the nasal processes of the superio maxilla. One girl of nine years had congenital hypertrophy of all the toes, resembling elephantiasis, but shown by the radiogram to be of norma osseous structure.

Hallux Valgus and Varus

Hallux valgus, in some instances, appears to be independent of boots Cases may be classified as (*a*) congenital; (*b*) rheumatoid; (*c*) due t boots.

The dislocation of sesamoid bones that takes place in hallux valgu is shown by the *x*-rays in the interosseus space. These bones have bee removed by some surgeons as the chief cause of the symptoms. Mr. Joh Poland has published some remarkable cases of hallux varus.

Bifid Phalanx

An excellent bifid terminal thumb phalanx is shown in the Röntge Atlas.[†] This should be compared with Dr. Beatson's case (p. 159). I he same volume are illustrations of various other deformities, such as humbless hands, missing and supernumerary digits, absent ulna, and so on. One plate (Tafel viii., 2) shows a supernumerary finger on each hand, with three phalanges articulated to the head of a bifid third metacarpal.

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[*] *Journal of the American Medical Association*, October 12, 1901.

[†] 'Atlas der normalen und pathologischen Anatomie.' Ergänzunsheft Tafel vii. 4.

Dr. F. Winnett* has published an interesting case showing absence of second phalanges in toes, with presence of rudimentary second phalanges only in two of the fingers. The condition was congenital, and was present in mother, grandfather, great-grandfather, and great-great-grandfather. Only about half the members of each family were affected. Dr. Winnett remarks: 'It is difficult to understand how parts of so great antiquity, and not prone to variation like parts highly and unusually developed, or like vestigial structures, can be so modified.'

Reproduction of Bone

An interesting case of reproduction of the diaphysis of the tibia after removal for acute infective periostitis and osteo-myelitis has been published by Mr. R. J. Pye-Smith.† The patient was a girl of nine: the main part of the shaft of the tibia was removed from its loosened periosteum, and the resulting cavity stuffed with gauze, while the fibula acted as a splint. The tibia was almost perfectly reproduced. (See Fig. 99, by courtesy of the *Quarterly Medical Journal.*)

Iodoform Stopping for Bone Cavities

A most interesting description of the filling up of the cavity in a bone after removal of a sequestrum or of carious matter has been devised by N. Hackmann.‡ He uses the iodoform stopping of Professor von Mosetig-Moothof, which adapts itself to every crevice, and is at the same time absorbable and aseptic. It is made of iodoform 30 or 60, olei sesami 20, and cetacei 40 parts. For details of the method the reader is referred either to the original article or to an abstract in the *Medical Review* for September, 1901, in which some interesting radiograms are reproduced, showing the various stages of filling and absorption. The method is applicable to cavities in bone, whether from osteomyelitis, necrosis or tuberculous caries, provided that they are previously rendered aseptic. The composition used is made so as to render absorption slow, and thus avoid the risk of iodoform-poisoning.

Bone Sarcoma

A sarcoma of the os calcis has been described by Professor Hector C. Cameron§ in a woman of sixty-eight, who had suffered for twelve months from pain in the ankle. A radiogram showed bulging on the planta aspect of the os calcis. The lower half of the bone gave a much lighte shadow than the upper half and the neighbouring bones. After operation

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* *Canadian Journal of Medicine and Surgery*, September, 1901, p. 198.

† *Quarterly Medical Journal*, May, 1901, p. 262.

‡ *Wien. Klin. Woch.*, May 30, 1901, p. 537.

§ *Glasgow Medical Journal*, May, 1900, p. 386.

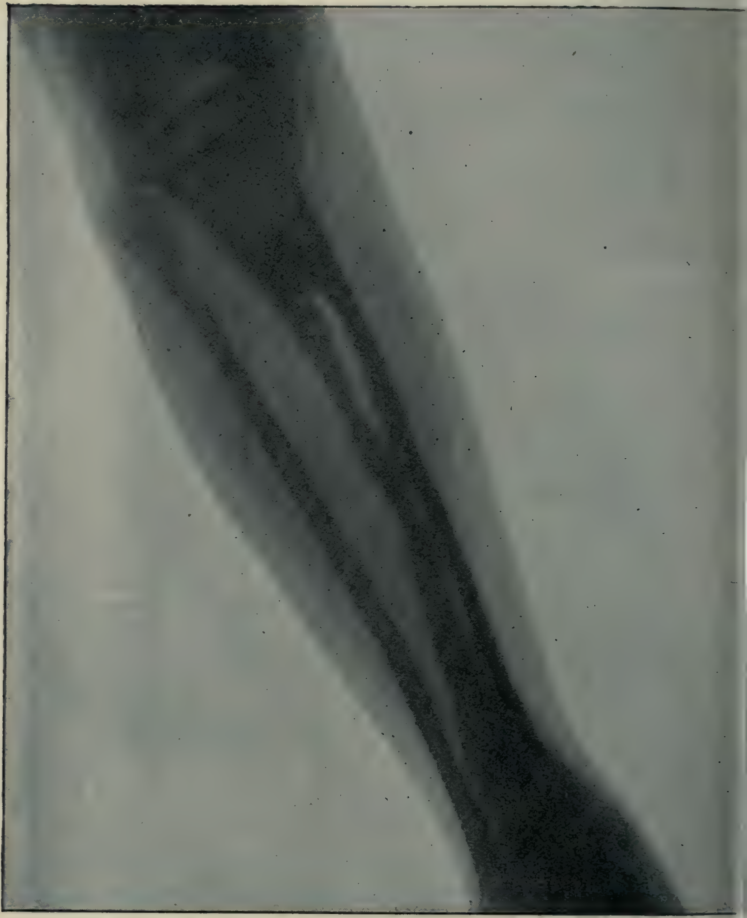

FIG. 99.—BONE REPRODUCTION.
Mr. Pye-Smith's case.

microscopic examination showed the tumour to be a round-celled sarcon with alveolar arrangement in meshes of delicate fibro-cellular tissue.

The diagnosis between benign osseous cyst and malignant osteo-sarcon is often one of no little difficulty. Both are slow and painless in the

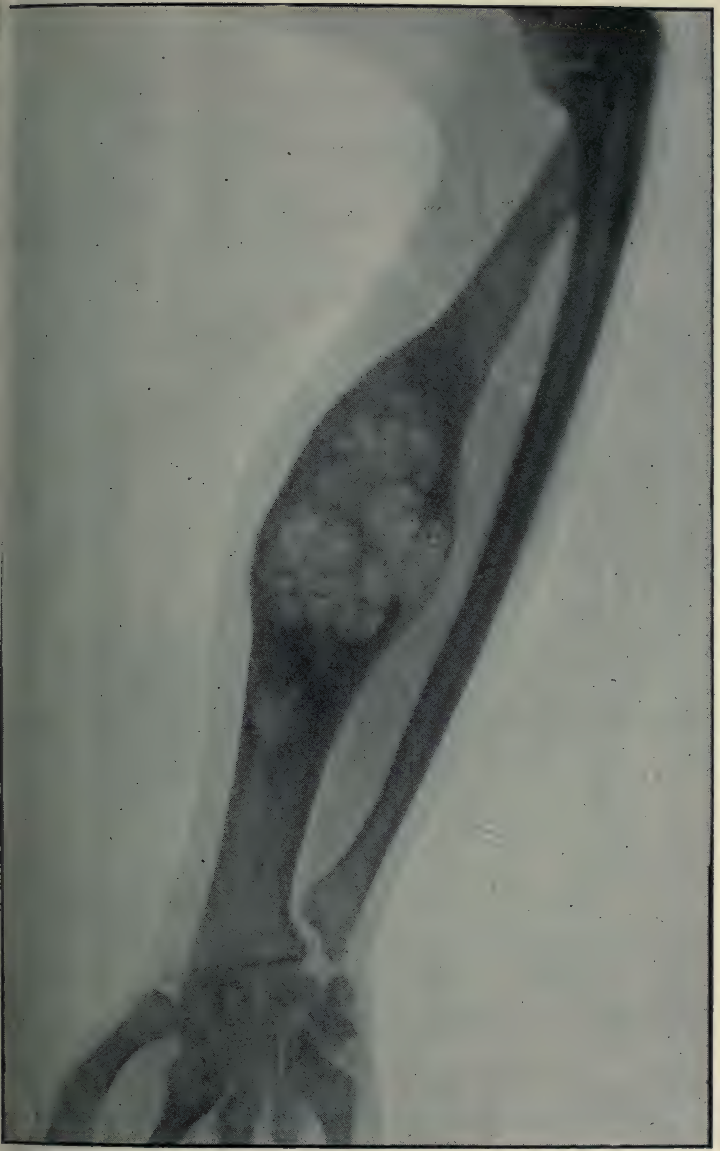

FIG. 100.—SARCOMA OF RADIUS.
From Addyman's 'Practical *X*-ray Work.'

onset, they occur in young people, often following an injury, and present more or less identical physical signs. It has been pointed out by Dr. Carl Beck * however, that in osteo-sarcoma 'the outlines of the bone always appear more or less abnormal and indefinite, some areas even appearing entirely translucent; while in osseous cyst the cortex appears thin and narrow, but well marked and regular. The fluid portion of the bone is entirely translucent, the light shade showing the same regularity. The adjacent epiphyses are normal. It is especially the regularity of the texture of the walls of the cavity as they appear on the skiagram which seems to me to be the characteristic feature of osseous cyst in contradistinction to the irregular texture of osteo-sarcoma.'

The same observer has recorded a case in which the Röntgen rays established a diagnosis of femoral aneurism which showed no pulsation on account of its extremely thick walls, and had been previously mistaken for osteo-sarcoma.

The accompanying figure is from a case of sarcoma of the radius under Mr. Marmaduke Sheild It shows excellently the radiographic appearance typical of that condition, and is here reproduced by courtesy of Mr. F. T. Addyman from his book on 'Practical *X*-ray Work.' (See Fig. 100.)

Scurvy Rickets

An excellent full-page illustration of a fractured femur in scurvy rickets has been published by Mr. C. G. Burton,† late of the North-Eastern Hospital for Children, London. It illustrates the bending and fracture of the bone in this rare condition, as well as the thinning of the compact wall of the femur and the rarefaction of the cancellous tissue.

Late Rickets

An interesting case of a girl aged seventeen, in whom rickets appeared at five years, has been published by Mr. E. Muirhead Little,‡ F.R.C.S. The patient wore splints and other supports from five years of age; at seven she took to crutches; at eight she fell and broke the right thigh above the knee, and afterwards the left. The deformity was chiefly in the femora; with their internal condyles touching, the distance between the internal malleoli was 14 inches. The lower ends of the femora curved backwards, and bent the legs at an angle of 75°. One of Mr. Little's chief reasons for calling the case 'late rickets' was the condition of the lower epiphyses of the forearm, as shown by radiograms. 'Instead of the narrow, clearly-defined zone separating the shadows of the diaphysis and epiphysis,' he writes, 'a wide, ill-defined blurred space intervenes.

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* *The American Journal*, June, 1901, p. 666.

† *Hospital*, October 7, 1899, p. 6.

‡ *Medical Press and Circular*, May 23, 1900.

In this space irregular deposits of lime-salts have produced dark streaks in the print. At the same time there appears to be some tendency to "cupping" of the bony ends of the diaphyses.'

Wiring Fractures

The accompanying radiograms (Figs. 101, 102, and 103) show the bones of the forearm in a lad of sixteen, before and after the operation of wiring.

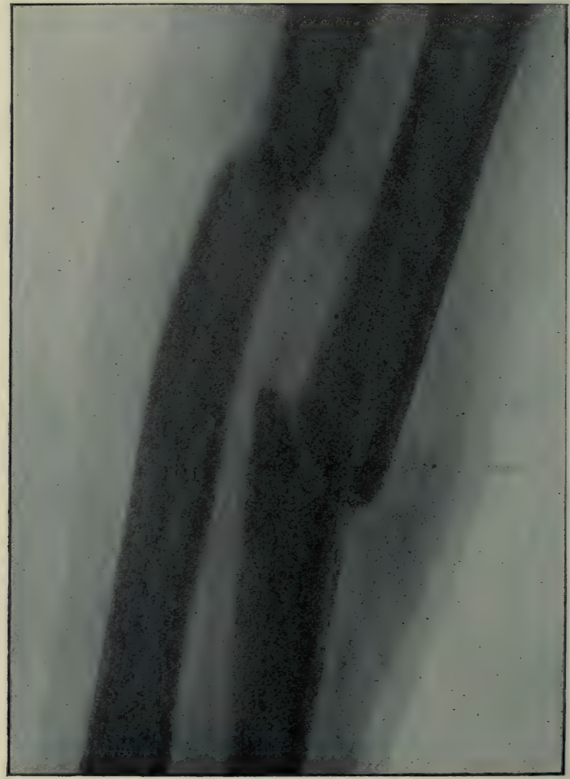

FIG. 101.—UNUNITED FRACTURE OF FOREARM: MR. LANE'S CASE.

The case was under Mr. Arbuthnot's care at Guy's Hospital.* The injury was of five weeks' standing. Both bones showed ununited fracture (Fig. 100), and the arm was flail-like.

Mr. Lane first freshened the broken ends of the ulna, and fastened them together with silver wire, and six weeks later treated the radius in a similar fashion. The result is shown in Fig. 103.

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* *Medical Press and Circular*, January 23, 1901.

Rupture of Tendons

In some cases the rupture of tendons can be demonstrated by means of the Röntgen rays. This is especially the case with the tendo Achillis the gap in which can be readily seen and measured from the radiogram. Mr. Lynn Thomas ruptured that particular tendon on the voyage out to South Africa in March, 1900. He has informed the writer that he followed up the changes radiographically at every stage, from the receipt of the injury until complete cure. In June, 1901, the united tendon was 1 centimetre thicker and wider than that on the uninjured side.

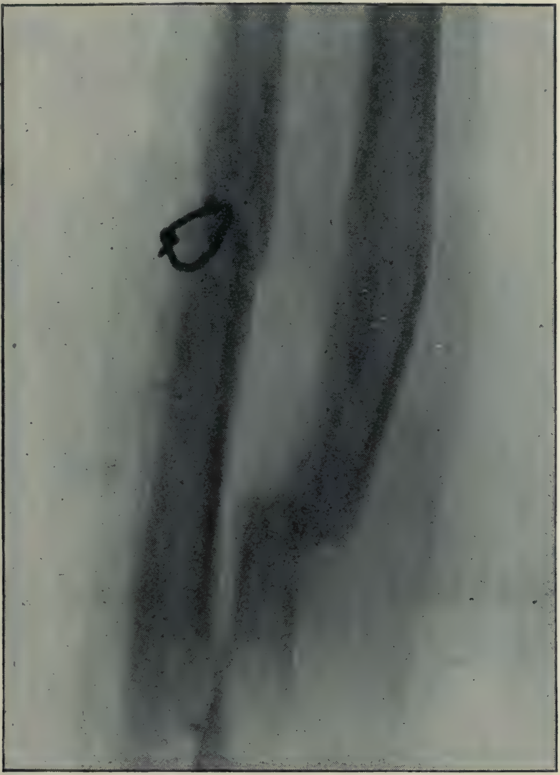

FIG. 102.—SAME FRACTURE AFTER WIRING ULNA.

Operation with Screen

Dr. G. W. Dunn* (Jarrow-on-Tyne), guided by shadow on screen, passed a small hook around a needle buried in foot, and extracted same. He had failed previously to find the foreign body by operation.

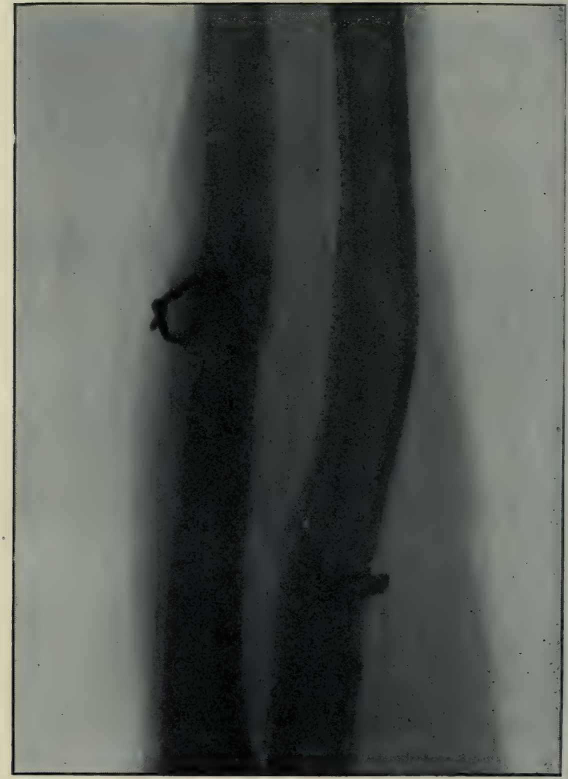

FIG. 103.—SAME CASE SOME TIME AFTER RECOVERY.

Hysterical Hip (Author's Case)

'The following case is of interest as showing an exaggerated instance of hysterical hip, and of the value of the negative evidence at times afforded by the Röntgen rays. The patient was sent to me by Dr. F. E. Fenton, of Ealing, in order to have a radiograph taken of the hip. She was then wearing a high-heeled shoe, and walked lamely, but the Röntgen photograph showed a perfectly normal hip-joint. Further examination showed bullet strikes the bones, partly [illegible] because of its effect in distorting the missile. The writer [illegible]ence of the [illegible]r, and no flatten[illegible] drawn between [illegible] of the buttock. It appears that two years previously to consulting Dr. Fenton she felt pain at times in the right side from the hip downwards as far as the knee. She went to a medical man, who treated her for hip-joint disease. She had the heel of her boot built up from time to time to compensate for the supposed shortening. On coming under Dr. Fenton's care he failed to find the usual signs of hip-joint disease, and the true nature of the condition was confirmed by the radiograph. The patient came of a markedly phthisical family, and was of a neurotic temperament.'*

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* *Lancet*, vol. i., 1899, p. 163.

MILITARY SURGERY

Discussing the best kind of Röntgen ray apparatus for military use, and the place in which the apparatus should be used, Borden arrives at the following general conclusions :

'First, the place for the apparatus is at general hospitals, permanent hospitals on the line of communication, and on hospital ships.

'Second, that, in equipping base and general hospitals for war service, coil apparatus, actuated by primary batteries, should be supplied.

'Third, that in permanently-established hospitals, where there is no dynamo current available, the static machine will probably give best satisfaction, especially if motor power can be had.

'Fourth, that in permanent base hospitals, or on hospital ships supplied with direct currents of 110 to 120 volts, the "break-wheel" apparatus will give the highest obtainable efficiency.'

The above was written in December, 1899, and deals with experiences of the year 1898. It is likely that equally good results might be obtained with mercurial breaks as with Edison's 'break-wheel.' The following description of the latter apparatus is taken from Borden's book.†

'The distinctive feature of the "break-wheel" apparatus is that there is no vibrator on the induction coil, its place being taken by an instantaneous air break-wheel device. This device consists of two toothed wheels mounted on the same shaft, the projections, or teeth, making contact with two flat brushes which bear on the outer peripheries, and by which the current is brought in and led out again. These wheels are rotated at very high speed by a small direct-current motor, which also runs a pressure-blower. The air blast from this blower enters a bifurcated tube, and is connected with two flat nozzles immediately over the contact brushes. When the device is set in operation by starting the motor and connecting the primary of the coil in series with the binding-post, the spark, formed at the contact brushes when the coil is energized, is instantaneously blown out by the air blast at the moment of formation.

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* *British Medical Journal*, October 19, 1901.

† 'Röntgen Ray in Spanish-American War,' p. 28.

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quently vastly augments the electro-moto coil. In consequence, Röntgen radiation of higher penetration passed efficiency is produced in the tube. The apparatus can be worked only by 110 to 120 volt direct current.'

Mr. Makins* has written an excellent book giving an account of his surgical experience in the South African War. It contains a number of excellent radiograms and descriptions of gunshot wounds. By the author's courtesy is inserted the accompanying figure, which should prove useful for the radiographer who is called upon to interpret gunshot fractures:

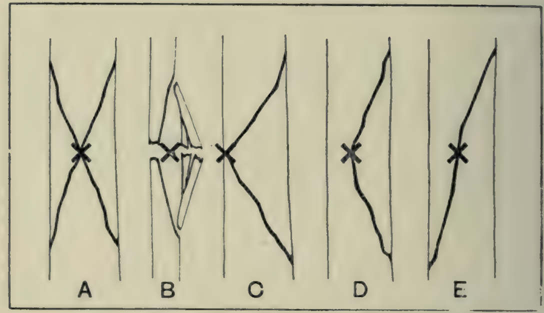

FIG. 104.—FIVE TYPES OF FRACTURE.

A, Primary lines of stellate fracture; wedges driven out laterally and pointed extremities left to main fragments. B, Development of same lines by a bullet travelling at a low degree of velocity; suppression of two left-hand limbs and substitution of a transverse line of fracture; a spurious form of perforation. C, Typical complete wedge. D, Incomplete wedge; impact of bullet, lateral or oblique, and two left-hand lines seen in A are suppressed. E, Oblique single line, one right and one left hand line seen in A suppressed. The influence of leverage from weight of the body probably acts here.

Mr. Clinton Dent,† special war correspondent in South Africa for the *British Medical Journal*, has given some interesting notes on bone injuries due to Mauser bullets. He concludes that the difference between such injuries inflicted at short and at long ranges is less than would be expected. A far more important factor is the part of the bone struck. Bullets striking the enlarged and highly cancellous ends of the long bones appear to drill without fracture only in certain positions, such as patella and lower end of femur; fracture is common with drilling of the tibia, upper and lower ends, and of the humerus and radius.

The extent of damage to the compact tissue of the shafts of long bones is naturally greater. A great deal depends on the angle at which the bullet strikes the bones, partly, no doubt, because of its effect in distorting the missile. The writer makes the pertinent remark that a line drawn between the apertures of entry and of exit does not afford a trustworthy clue of the course of the bullet.

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* 'Experiences of the South African Campaign,' G. H. Makins, F.R.C.S., late Consulting Surgeon South African Field Force.

† *British Medical Journal*, April 21, 1900, p. 969.

On the whole, he does not advise immediate radiography in the case of fractured femurs at the front. The difficulties, he points out, in getting a satisfactory radiogram of that part in a muscular young man are considerable. The patients have to be transported a long distance, and any good that might be gained by a radiogram would be more than counterbalanced by the harm that would result from disturbing the patient. The use of the rays, therefore, was usually deferred in injuries of the long bones of the lower extremity until some union had taken place.

Bullet lodged in the Axilla

In this case a radiogram, taken by Dr. E. G. J. G. Calverley, of the Portland Field Hospital, showed a bullet lying between the axilla artery and vein. The entrance wound was a little above the incision of the deltoid muscle. The bullet was removed by Mr. Anthony Bowlby.*

Gunshot Wound of Brain

An interesting case is related by Borden† of a private soldier who on March 27, 1899, was shot in the head by a Mauser bullet, which entered an inch above the supra-orbital ridge slightly to the left of the middle line. The foreign body was found by the Röntgen rays to be lodged in the left occipital lobe. Six months after the injury his general condition was good. He suffered pain at times in the lumbar region and in front of the left parietal eminence. There was no loss of power on either side, but some weakness in right arm and legs and a slowness in response to mental impulse. No epileptiform seizures, no disturbance of nutrition or bodily functions. The patient afterwards entered the mail service, and returned to Manila on duty.—*Reported by Major A. C. Girard, Surgeon U.S.A. Army.*

Gunshot Injuries of Spine

Borden‡ relates two cases of bullet injury to the spinal cord. In both instances a radiogram showed that the missile lay outside the spine.

'Case 12.—*Gunshot injury of the cord; Mauser bullet lodged in back; localization by Röntgen ray; removal; discharge for disability.*

'C. J. E., private, wounded at Malate, Philippine Islands, June 31, 1898. Bullet entered at a point over the middle of the left deltoid muscle, opposite the surgical neck of the humerus. At the time of the casualty the arm was deflected from the thorax at an angle of about 60°. There was no wound of exit. Immediately upon receipt of the injury the patient fell to the ground, and there was complete paralysis, involving both the upper and the lower extremities. He was removed to the hospital, soon became unconscious, and remained so for two days.

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* For excellent illustration, see *Intercolonial Medical Journal of Australasia*, September 20, 1900, p. 452.

† 'Röntgen Ray in Spanish-American War.' For full details of this case see p. 42.

‡ *Ibid.*, p. 40 *et seq.*

There was no discoverable active hæmorrhage or fracture. Reflex functions, so far as it was possible to ascertain, were entirely absent below that portion of the spine where the injury was supposed to be. There was rectal and vesical paralysis. After an interval of three weeks, during which time there was no improvement, he began to regain control of his arms. A progressive change for the better was inaugurated, followed by partial restoration of power of movement. Complete sensibility, both as to pain and temperature, returned to the right half of the body. He was transferred to the Division Hospital, Presidio, San Francisco, October 22, 1898. At that time he was able to walk, though with great difficulty. On his arrival at Presidio there was a loss of electro-contractility, as to sensibility, in the left arm, forearm, and hand, left half of the thorax, left half of the abdomen, and left leg and foot. There was loss of sense of temperature over this area. Tactile sense, however, was generally present. A partial paralysis of the sphincter ani and vesicæ persisted. Knee-jerk increased on right side, feebly present on left side. Motion of the extremities was almost completely restored. Symptoms in reference to the brain negative. Sexual power and desire almost nil. No ankle clonus. No irregularity in any of the internal organs, but a languid and sluggish condition, lacking the power of vigorous action.

'January 2, 1899 : Motion now only slightly impaired in left upper and left lower extremity. Co-ordination of muscles virtually normal. Power of muscles is inhibited in right leg. Electro-sensibility absent in left lower extremity, extending from the crest of the ilium to the plantar surface of the foot. There is also loss of the sensation of temperature over this area. Sensibility completely absent in left leg and foot. Mobility absent in left foot. Micturition and defecation disturbances are still present. Sexual power is diminished, but desire is normal. As far as he can remember, there has been a constant dull pain in the back in the region of the third intercostal space, an inch and a half to the right of the spinous process of the third dorsal vertebra. A radiograph shows a lodged Mauser bullet at the point where the pain above mentioned exists. Bullet was extracted March 7, 1899, and, as the patient remained disqualified for military service, he was finally discharged on account of impairment of mobility of right leg and thigh and loss of sense and contraction of the left leg.'—*Case reported by Major W. S. H. Matthews, Surgeon U.S. Volunteers.*

'*Case* 13.—E. M., reporter, wounded at La Quasimas, July 24, by Mauser bullet, which entered the back an inch to the left of the spine at level of sacro-lumbar articulation. Complete paralysis of the lower extremities and loss of sensation followed the receipt of the injury. Patient entered the Roosevelt Hospital in New York, where Dr. Abbé took a radiograph of the case, which located the missile lying butt-end foremost one inch to the right of the first lumbar vertebra, and deeply placed in the neighbourhood of the renal vessels.

'The position of the bullet precluded the possibility that the symptoms were due to the pressure from the missile. Dr. Abbé did a laminectomy, and removed all the depressed fragments of bone which were pressing on the spinal cord. The bullet was not removed.'

The latter case especially indicates the value of knowing the exact state of matters as regards the muscle and the spine. The surgeon was furnished with grounds for laminectomy and for leaving the bullet alone.

Location of Bullet in Tongue

Marcus and Boisson* reported to the French Academy of Medicine a case in which a bullet was located and removed from the hyoglossus muscle by the x-rays. After the operation a hysterical hemiplegia disappeared.

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* *Gaz. des Hôp.*, September 22, 1898.

Nimier and Laval[*] have published an interesting article upon accidental poisoning due to the retention of lead missiles. They give an illustration showing a great number of No. 9 shot, many of them misshapen or reduced to fragments, scattered along the track of a wound between the knuckles of the hand and the lower half of the forearm. There appear to be some hundreds of pellets and metallic fragments. Abdominal colic, a blue line on the gums, and other signs of lead-poisoning, occurred. Operation on the arm was followed by recovery with good movement of the fingers.

FOREIGN BODIES

Leg

In a case under the writer's care, a young woman had run a broken needle into the leg. On examination, a puncture was seen with a localized swelling of about ½ inch in length. A Röntgen ray photograph showed the absence of any foreign metallic body. The swelling was, no doubt, due to septic inoculation.

(Note the value of negative evidence : In deforming joint conditions, especially in the young, it is often a valuable aid to diagnosis and treatment to ascertain the absence of disease in bones.)

Foreign Bodies in Stomach

Dr. W. S. Halstead,[†] Professor of Surgery, Johns Hopkins University, has published a radiogram of the stomach of a juggler, aged twenty-one, from whom he removed 208 foreign bodies and 74 grammes of glass by the operation of gastrotomy on March 14, 1900. Recovery was rapid and complete. The list of articles removed included 20 pieces of small dog-chain, 8 pieces of other chain, 54 wire nails, 35 ordinary nails, 7 knife-blades, and numerous other things.

Professor Halstead does not mention the total weight of the articles removed, but he has appended an excellent epitome of the literature of foreign bodies removed successfully by gastrotomy. A girl of ten years, under Mr. Mayo Robson's care (see *Lancet*, 1894, p. 1028), furnished the record number.

This case should be compared with the one figured on p. 109 of the present volume. Dr. Halstead's radiogram shows an equally blurred outline of stomach contents, with no indications of the details of the contained mass of articles.

A Nail in the Trachea

Dr. Garel[‡] reports a case of a child aged twenty months who swallowed a nail 2 inches long, which was thought to have passed into the stomach.

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[*] *Le Caducée*, Journal of Army Medicine, September 7, 1901, p. 53.

[†] *The Johns Hopkins Hospital Reports*, vol. ix., 1900, p. 1054.

[‡] *Therapie*, D. Gevenwart, June, p. 250.

Some time after, as the child was getting thin, and a radiogram showed the foreign body to be in the windpipe, the nail was removed by a powerful electro-magnet through a tracheotomy wound.

Œsophagus

Segond* removed a toothplate successfully by left external œsophagotomy. The foreign body was located by the rays at the level of the interclavicular notch. The plate had a metallic hook which ran into the wall of the gullet, so that the foreign body 'required considerable location' before it could be dislodged.

A lady's hat-pin was demonstrated in the gullet of an infant aged fifteen months under Mr. Ballance at St. Thomas's Hospital. It was lodged at the lower end of the œsophagus, the head being about the level of the cardiac end of the stomach. The pin was removed by a small incision in the stomach wall.

A most interesting case of removal of a toothplate from the œsophagus of a lunatic patient has been recorded by Dr. Nathan Raw.† The foreign body was seen with the fluorescent screen to be lying at a point a little below the upper end of the sternum, apparently fixed transversely across the gullet. An hour's patient trial with the forceps failed to remove the foreign body. With the aid of the screen, however, a long forceps was guided down to a projection of the plate, which was extracted with the use of considerable force. The patient lost a good deal of blood, but made a good recovery.

Abdomen

J. H. Morgan‡ removed a piece of stay-busk from the stomach of a man; no x-ray record, because metal was perpendicular to the sensitive plate.

N. Davies Colley§ removed a packing-needle, 4 inches long, swallowed by a woman of thirty-six four months previously. She had obstinate constipation and painful swelling, 2 or 3 inches in diameter, above front half of left iliac crest. With the rays the needle was visible, lying in a nearly vertical position. On cutting through the muscles some fibrinous exudation was found upon the transversalis muscle. On the supposition that the needle had been pushed back into the bowel, the wound was then closed. A month later, the needle not having been passed per rectum, it was removed from the descending colon by operation. A good localizing radiogram had been previously taken, which showed that the needle lay vertically about halfway between the middle line and the outline of the flank. Its lower extremity was reckoned to be 2½ inches from the surface, and its upper extremity a little further back. A noteworthy point was the rapid absorption of adhesions in the interval between the two operations.

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* *Lyon Médicale*, August 5, p. 490.

† *Liverpool Medico-Chirurgical Journal*, September, 1901, p. 345.

‡ *Lancet*, February 5, 1898.

§ *Ibid.*, January 13, 1900, p. 96.

Foreign Bodies in Neck

Mr. R. Clement Lucas localized by the x-rays, and subsequently removed, a bullet from the front of the second cervical vertebra. The case was reported in the Surgery Section of the British Medical Association at Portsmouth on August 2, 1899.

Bullet in Back

A bullet was discovered by means of a radiogram lodged near the dorsal spine of Maître Labori, the brilliant counsel who defended Captain Dreyfus. He had been shot in the back by an assassin, and his political opponent did not hesitate to assert that the alleged attack was merely a trick to gain sympathy. The demonstration of the bullet by a Röntgen photograph afforded conclusive proof to the contrary.

In the case of President McKinley, the x-rays were not used to locate the bullet. It seems likely that the surgeons in attendance regarded the evident wound of the stomach as the indication for operation without a moment's delay. As shown in the result, the progress of the case would not have been otherwise had the bullet been located and removed.

Foreign Bodies in Eye

With regard to ophthalmic surgery, Mackenzie Davidson* has improved his localization methods in various way. He has applied stereoscopy with much success in the examination of the eye, and the apparatus generally has been improved and simplified. 'Stretched piano-wires are now employed,' he writes, 'instead of knitting-needles, and the point from which the x-rays originate on the anode can be quickly centred by viewing it over a rod with a rifle-sight properly placed, and so adjusting it that the point where the piano-wires intersect eclipses the radiant point, which glows visibly when the tube is in action.'

Detection of Urinary Stone

Improved apparatus has enabled operators to detect stone in the bladder, kidney, and ureter with much greater precision and certainty than formerly. The position of the rays with regard to renal calculus has been fairly summed up by Mr. P. J. Freyer,† as follows :

'The circumstances which militate against the success of this method of diagnosis are : The stone being small, the patient being stout, the movements of the kidney during respiration blurring the image, the shadow cast by the stone being concealed by that of the bones, and the calculus being phosphatic, any one or more of which may render this process nugatory. When a distinct isolated shadow resembling a stone is shown, you may be pretty certain that there is one present. But negative evidence as to the presence of stone by the Röntgen rays should not deter you from exploring the kidney by operation when the symptoms of stone are well marked.'

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* See Transactions of the Ninth International Ophthalmic Congress, Utrecht, 1899, and article in vol. xix. of the Ophthalmological Society's Transactions.

† *British Medical Journal*, May 25, 1901, p. 1258.

Renal Calculus

This subject is discussed by Dr. C. L. Leonard* in an article dealing with fifty-nine suspected cases, in twelve of which a positive result was obtained. One negative result proved misleading, as a calculus was afterwards found. The error in that instance was due to the use of too small a plate.

Jonathan Hutchinson, junior, F.R.C.S.,† read an excellent paper before the Section of Surgery at the Cheltenham meeting of the British Medical Association.

'The skilled use of the Röntgen rays,' he remarks, 'will now rarely fail to demonstrate both the exact position and the size of any renal stone. The early and positive recognition of the latter not only secures resort to operation before the calculus has led to secondary degeneration of the kidney, but in certain doubtful cases the proof afforded by the rays that no stone exists will save the patient from an unnecessary, and possibly dangerous, exploratory operation. In no department of surgery has the discovery been of more practical use than in that of the kidney. It is especially with regard to the kind and severity of the operation required that the *x*-rays are so valuable. They will, for example, in a given case tell the surgeon that there is a single stone 1½ inches long placed transversely 3 inches from the first lumbar spine and the same distance from the iliac crest. The operation becomes then merely the extraction of a somewhat deeply-placed foreign body. There is no object for an incision longer than is required to give free access, and still less for disturbing the relations of the kidney or forcibly dragging it into the light of day, or for prodding it in all directions with needles.'

The accompanying radiogram of a renal calculus is reproduced by courtesy of the author.

Mr. Hutchinson's conclusions are:

1. The *x*-rays (except, perhaps, in stout subjects, or in the case of very small stones) enable an exact diagnosis as to size, position, and number of renal calculi to be made.

2. They enable the surgeon in performing the operation of nephrolithotomy to do so with the least possible injury to the kidney, and to dispense with bringing that organ to the surface of the wound.

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* *Annals of Surgery*, 1900, p. 162.

† *British Medical Journal*, October 19, 1901, p. 1131.

3. Limited incisions made directly over the calculi through the renal pelvis are to be preferred when practicable. Such wounds of the pelvis heal well.

4. Before the operation it is most important to get the urine in a healthy condition.

5. Renal calculi, however small, should be operated on as soon as they are diagnosed. Their danger to the kidney structure and to the patient's life bears no relation to their size.

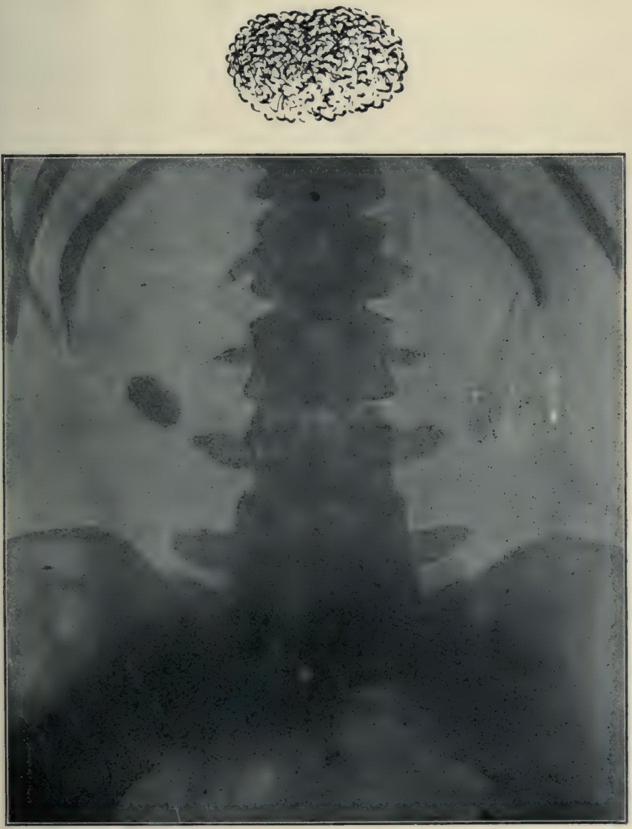

Fig. 105.—Stone in Kidney. The Stone is shown above full size; Plate reduced.

With regard to renal calculi, it may be remarked that there is no method yet devised of securing a radiographic record in the case of very fat patients. Hence, in giving details of cases, it is always important to note the girth of the person as well as the length of the exposure. It is certain that no renal calculus could be taken in fifteen seconds, except in the case of a very thin subject. With the most powerful modern apparatus five minutes is needed to get through the abdomen of a stoutly-built man—say 40 inches round the chest. In a patient who measured 45 inches round the abdomen, the present writer (Dr. Walsh) was able to secure a record of ribs and spine, but showing no sign of calculus. That result was obtained with a five minutes' exposure with the antikathode at a distance of 22 inches from the sensitive plate. To procure that result, however, numerous experimental exposures were required, and it is probable that most radiographers would decline to attempt the search for a renal calculus in a patient of so large a girth.

Stone in Ureter

Many cases of stone in the ureter have been located by the rays. Dr. J. W. Elliott* reported a case in which a calculus was shown in the right ureter, just above the crest of the ilium, from which position it was readily removed by operation. He alluded to six other cases mentioned by Leonard.

A good case has been published by W. W. Keen, M.D.,† of a calculus located in the ureter by the Röntgen rays and afterwards removed by operation. The patient was a boy of ten years, who had a history of an attack of hæmaturia at two years of age. From five to ten there were recurrent seizures of pain in region of left kidney, extending to scrotum and penis. The calculus, which was rough and dark, consisted of calcium phosphate, and lay in a pouch partly intra-ureteral and partly formed between the ureter and the rectum.

FRACTURES AND DISLOCATIONS ‡

Formation of Callus

Manoury§ of Chartres called attention to the formation of callus as watched by the radiograph. At the end of a dozen days there appears at the extremities of the fragments a light cloud that gradually becomes denser. If the fragments be accurately apposed, the callus forms at the level of the fracture a diffuse globular mass, which little by little becomes fusiform and compact. If there be slight overlapping, a cloudy deposit closes the medullary canal of each fragment, and makes a thick layer laterally at the level of contact. The time of formation of a definite callus is variable, and depends upon the thickness of the bone. In certain cases —especially oblique fractures of the tibia—the callus may remain for a long time invisible, almost up to the time of complete union.

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* *Boston Medical and Surgical Journal*, May 16, 1901, p. 474.

† *Journal of the American Medical Association*, August 31, 1901, p. 567.

‡ This section has been revised by Mr. Lynn Thomas, F.R.C.S.

§ Thirteenth International Congress of Medicine, Paris (Section of Surgery), August 3, 1900.

The above evidently applies to the ossification of a subperiosteal callus, which, in the opinion of most English surgeons, would not be formed if absolute immobility were obtained.

Dr. C. L. Leonard,* of Philadelphia, writes :

'The advent of the Röntgen method into the diagnosis of fractures has created a higher standard by which the results obtained in the treatment of fractures must be judged. The practitioner can no longer be said to have employed all the means and knowledge to the best of his ability in the treatment of a fracture unless he has employed, or suggested to his patient the employment of, a skiagraph. In addition, if the skiagraph shows that perfect coaptation and fixation have not been secured, he must, at least, offer his patient the alternative of operative intervention, and employ it if it is desired.'

Old Green-stick Fracture of the Humerus

A curious case of this kind has been reported by Mr. E. W. H. Shenton,† of Guy's Hospital.

The injury was of three years' standing before its nature was cleared up by the Röntgen rays. Those who previously examined it said unhesitatingly that both the bones of the forearm were dislocated outwards, but the curious point was that the movements of the joint were quite perfect.

The explanation furnished by the radiogram was that the external condyle remained in its proper place while the articular surface was 'skewed' inwards. The fracture must have been undiagnosed at the time, and had the Röntgen rays been available the patient might have been saved the deformity.

Fractures about Elbow-joint

A lady cyclist fell while dismounting from her machine ; her elbow was injured, and the dislocation diagnosed and reduced. After months of persevering exercise movement was restored ; but a hard lump could be felt in front of the joint, the nature of which was open to speculation. On being examined by the Röntgen rays, the cause of the lump became apparent in a splinter of bone an inch and a half long embedded in the muscle. This bony fragment had evidently come from the humerus ; at the same time the head of the radius showed an impacted fracture. Neither fracture had been diagnosed at the time by the surgeon who attended the case.‡

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* *New York Medical News*, February 23, 1901, p. 286.

† *Physician and Surgeon*, March 22, 1900.

‡ E. W. H. Shenton, *Physician and Surgeon*, March 22, 1900.

Fractured Olecranon

Mr. F. D. Bird has published a radiogram showing the advantages of open suture in fracture of the olecranon. The accident had taken place three months before the operation, and the arm was almost useless. A thin slice was sawn off each of the fragments, which were then brought together by platinum wire passed through them from side to side. That method, in the opinion of the operator, gives a better grip and more accurate approximation than vertical sutures.

Mr. Shenton* mentions a case in which the olecranon was not only completely severed from the shaft of the ulna, but was also fractured vertically. He suggests that perhaps a more valuable use of the Röntgen method than the power of actual diagnosis is the facility it presents for watching the progress of a fractured olecranon as regards recovery.

Forearm

Fracture of the lower end of the radius with anterior displacement, the so-called 'Smith's fracture,' is described with illustrations of cast and a radiogram by Dr. John B. Roberts,† of Philadelphia.

He refers to a monograph on the subject presented to the American Surgical Association in 1896, recording a number of cases from his own practice and from other sources. The radiogram is that of an old case, and shows the prominent lower end of ulna projecting, so to speak, over the displaced carpus.

Hand

As anticipated, the Röntgen ray methods have shown that metacarpal fractures are more common than was formerly supposed. There is usually little displacement, since the adjoining metacarpal bones act as efficient splints.

In some cases where there is lateral displacement, union in a bad position may lead to much deformity and loss of function. Reduction is always easy if the exact nature of the injury be known; it is therefore desirable in such cases to examine the fracture by means of the Röntgen rays.

A good account of this injury is given by Dr. Carl Beck,‡ of New York. He describes a case in which a man sustained fracture of the fourth metacarpal in striking a blow with his fist.§

Dr. Beck treats these fractures by a simple splint made of two rubber drainage-tubes lightly pressed into the adjoining interosseous spaces, and kept in position by strips of plaster passed round the hand.

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* E. W. H. Shenton, *Physician and Surgeon*, March 22, 1900.

† *Philadelphia Medical Journal*, March 9, 1901, p. 482.

‡ 'Treatment of Fracture of the Metacarpal Bones,' Carl Beck, M.D., *New York Medical Journal*, August 4, 1900, p. 177.

§ For abstract of case, with illustrations, see *Medical Review*, November, 1900, p. 687.

Dr. G. T. Beatson, of Glasgow, has published an excellent illustration of the so-called 'stave of thumb,' or Bennett's fracture. The fracture is an oblique detachment of the palmar half or more of the articular surface of the metacarpal bone facing the trapezium, while, in addition, the entire metacarpal bone, except the little piece of the base so separated, has slipped backwards, no doubt through the action of the extensor ossis metacarpi and other muscles, and this simulates a dislocation of the bone in that direction.

In his original description Professor E. H. Bennett, of Dublin, says that fracture of the metacarpal bone is more common than that of any other of the metacarpals; and, further, that, when the fracture occurs in the metacarpal bone of the right thumb, it is not just above the middle, as is usually asserted, but that it is situated at the base of the bone. The injury simulates dislocation, and is commonly regarded as a sprain of the thumb. When untreated, after a long period of disability it unites with slight deformity.

Simple Fracture—First Phalanx

So far as we know, this injury appears to be rare apart from compound fracture.

A case is reported by M. Estrabaut[*] of a man whose forefinger swelled considerably after striking another man with his fist. A radiogram showed an L-shaped fracture involving half the articular end of the first phalanx, and extending thence obliquely down the shaft of the bone.[†]

Lower Limb

A. Barker reported a stellate fracture of patella, the result of direct violence, that might have been overlooked but for the x-rays.

Dr. J. N. Henry[‡] reports a case of two fractures of the knee-cap, one following eight months after the other. Only one fracture could be felt, but the radiogram showed two fractures in a greatly enlarged knee-cap, measuring 3¼ inches in length. This result bears out a statement of Hamilton, that five months after the fracture of the knee-cap refracture is not more likely than if the previous fracture had not occurred.

Tibia

Dr. J. Griffiths,[§] Reader in Surgery at Cambridge, has shown that spiral fracture is the most common form of fracture so far as the tibia is concerned. This view has been confirmed by numerous observations on radiograms of fractures in question taken at Guy's Hospital.

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[*] *Gazette des Hôpitaux*, August 9, 1900, p. 909.

[†] For radiogram, see *Medical Review*, October, 1900, p. 629.

[‡] *American Journal of Medical Sciences*, August, 1899, p. 183.

[§] *British Medical Journal*, April 21, 1900, p. 948.

With regard to the indications for operation in such fractures, Mr. Golding Bird says that operation is called for in cases where the suitable manipulations required by the oblique or spiral fracture fail to give a good position. The procedure need not, of necessity, involve wiring, or even screwing, for sometimes the fragments when replaced do not tend to move. This, however, is not generally the case, and the addition of a wire, which does not add to the gravity of the treatment, makes assurance doubly sure.

What degree of 'riding fragment' calls for operation must be determined by the surgeon in each case. To operate in order to obtain an absolute linear adaptation of the shin-bone that will stand the test of the radiogram is not justifiable. A slight displacement—say one-eighth of an inch—looks large when photographed, and can certainly be felt by the finger; but it is not only of no importance, but will have disappeared by the natural modelling processes that take place in the course of a few months. Where, however, the 'riding fragment' threatens to become compound, or where there is shortening, or where the foot cannot be placed in its proper line and retained there, then it is (circumstances permitting, and if the best results are to be obtained) that operation is, in my opinion, called for.

Under these circumstances, the term 'rare' applied by Dr. Taft, of Boston, to a spiral fracture of the tibia (Fig. 62, mentioned on p. 143) is no longer tenable. At that time the frequency of spiral fracture of the bone in question had not been generally recognised. Indeed, the possibility of arriving at any definite conclusion with regard to its occurrence could hardly have arisen apart from the facts revealed by the Röntgen methods.

Foot

Before the introduction of the Röntgen methods, fractures of the metatarsal and tarsal bones were almost unknown. These injuries, which we now know to be fairly common, were regarded as sprains, and not infrequently treated by massage, whereby a displacement of the fragments was no doubt occasionally increased.

Fracture of Os Calcis

A case of fracture of the upper part of the bone attached to the tendo Achillis has been reported by Mr. Southon.* No crepitation could be made out, and the diagnosis was obscured by effusion of much blood. By the help of a radiogram the nature of the injury was revealed, and successful treatment carried out by wiring the fragments and fixing the foot so as to relax the calf muscles.

Fracture of Metatarsal

H. L. Barnard relates a case in which all the metatarsals of a labourer's foot were broken by a fall upon the foot from a scaffold. The base of the first metatarsal bone was impacted. For a description of this interesting case with an accompanying radiogram, see the *Practitioner*, October, 1901, p. 425.

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* *Medical Chronicle*, June, 1900.

Dislocation of Neck

Case reported by Noble Smith* at the Windsor and District Medical Society.

A lady sustained a fall of 80 feet down some rocks in the island of Sark. After several weeks' rest she began to get about again, and then suffered from pain and stiffness in her neck and attacks of giddiness; at the same time she would suddenly fall down. On examination, an angular deformity was detected between the fifth and sixth cervical spines, and a radiogram clearly indicated a partial displacement between those vertebræ. The dislocation was reduced under an anæsthetic.

Separation of Upper Epiphysis of Femur

Mr. H. L. Barnard, F.R.C.S.,† says that at least fourteen definite cases of separation of the upper epiphysis of the femur have been recorded, in which the diagnosis was confirmed by operation, autopsy or radiogram. He quotes ' Progressive Medicine,' vol. iv., 1900, p. 148.

Separation of Lower Epiphysis of Femur

In an important article, Messrs. J. Hutchinson, jun., and H. L. Barnard describe four cases of this injury treated at the London Hospital, and mention sixteen others of which they have had personal knowledge. The injury is nearly always the result of forcible hyper-extension of the knee, and if displacement occurs, it is just as constantly a forward one of the epiphysis. By means of the Röntgen rays it was shown that in the extended position of the knee, even with an anæsthetic, reduction of the fragments was very difficult, if not impossible. The further important observation was made that with full flexion reduction was always easy. When treated in that way the usual result was rapid recovery, with perfect movement of the knee, and without shortening or deformity of the leg. (See Figs. 106, 107, 108.)

Dislocation of Patella

Two cases of exceedingly rare dislocation of the patella have been published by Dr. David Newman and Dr. H. Rutherford.‡ In the first case there was dislocation upwards by rotation of the patella on its horizontal axis, while the articular surface presented upwards. The second case is probably unique. An accompanying radiogram shows the patella 'with its articular surface turned downwards, and engaged between the femur and the tibia. The ligamentum patellæ is seen tightly stretched.'

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* *Lancet*, March 3, 1900, p. 422.

† *Practitioner*, October, 1901, p. 395.

‡ *Lancet*, June 22, 1901.

Dislocation of Astragalus and Metatarsus

Mr. Robert Jackson, M.B.,* describes a case of fracture of the neck of the astragalus, with dislocation of the bone backwards, in a collier. He met with an accident in March, 1898, and was first seen by the writer in October. He had not been able to walk on the foot since the accident. A bony mass was seen and felt under the tendo Achillis and above the os calcis, and there was little or no movement of the ankle-joint. He refused operation at the time, but returned in February, 1899, asking to have the bone removed. This was done, and he left hospital at the end of a month. In the following July he could walk six or eight miles with ease, and was still improving. After that he returned to his work in the pit.

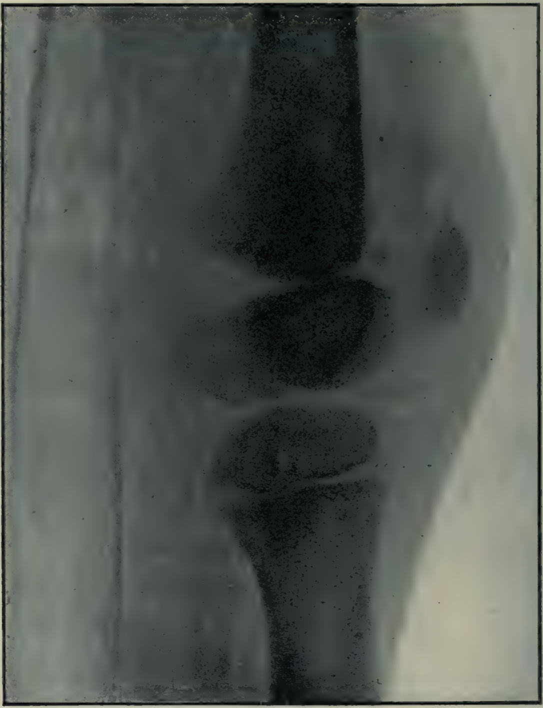

FIG. 106.—SEPARATION AND DISPLACEMENT OF LOWER FEMORAL EPIPHYSIS. Hutchinson and Barnard.

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* *Quarterly Medical Journal*, February, 1900, p. 194.

The measurements after recovery round the heel and instep were the same on both sides, the only measurements that differed being the length of the foot and the length of the legs, both of which were three-quarters of an inch less on the right than on the sound side.

A good illustration of dislocation of the metatarsus has been published by L. H. Harris,* of Sydney.

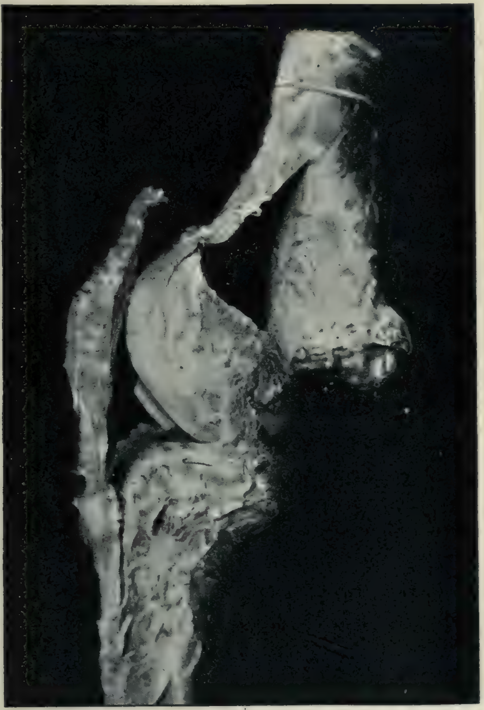

FIG. 107.—DISSECTION OF DISLOCATED FEMORAL EPIPHYSIS. (*Medical Review.*)

Dislocation of the Epiphysis of a Metacarpal Bone

Mr. E. H. Herring,† of Ballarat, found the above rare condition in a boy of ten, who had injured his hand by a fall from a tree. On examination there was found on the palmar surface of the right hand over the neck of the first metacarpal bone a small, immovable, rounded, hard nodule, of about the size of a pea. Several medical men diagnosed the case as one of exostosis. Treatment failed to keep the nodule in place, and finally it was excised.

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* *Archives of the Roentgen Ray*, January, 1901.

† *Lancet*, April 21, 1900, p. 1131.

Separation of Metacarpal Epiphyses

Mr. H. L. Barnard has published a description with a capital radiogram of separation of the epiphyses of the heads of the four outer metatarsal bones in a boy aged thirteen. The end of one diaphysis made a painful projection on the dorsum of the foot, and was removed by Mr. Mansell-Moullin.

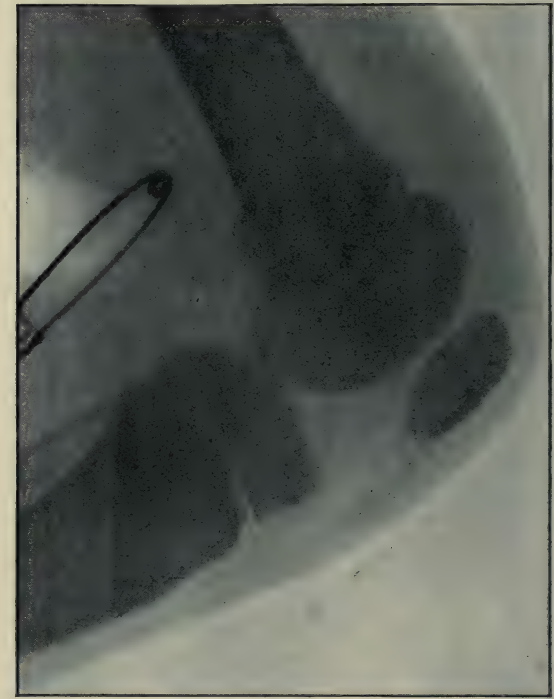

FIG. 108.—SHOWING REDUCTION OF LOWER FEMORAL EPIPHYSIS BY FLEXION (*Medical Review.*)

Dislocations of Knee and Foot

An instance of this somewhat rare injury was reported by Mr. T. P. Carlion,* from Woolwich Arsenal.

The injury was caused by a sack striking the inner side of the leg while the thigh was fixed from the outside.

Mr. R. J. Pye Smith,† of Sheffield, has published radiograms showing the foot dislocated backwards, and also showing the result of operation effecting the reduction after removal of a large portion of the astragalus.

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* *British Medical Journal.* See radiogram, December 1, 1900, p. 1568.

† *Quarterly Medical Journal,* August, 1900, p. 405.

The same surgeon has published a case of fracture of the shaft of the ulna, with dislocation of the head of the radius. The injury had taken place some little time previously, and the radiogram revealed a remarkable amount of new bone surrounding the dislocated head of the radius. Reduction being found impossible without operation, the head of the radius was excised together with the new bone which appeared to have been thrown out by the periosteum of the humerus.

In the same paper he reports a traumatic dislocation forwards of the head of the fibula.

DENTAL

Kolznecht* has reported a case in which a patient swallowed a set of artificial teeth on a plate during sleep. A Röntgen photograph failed to detect the foreign body. A few days afterwards it was detected by a screen examination lying in the œsophagus, just where the latter passes through the diaphragm. The pulsating object could be seen through the heart, and during the act of swallowing was observed to rise about an inch.

MEDICAL

Acromegaly

An interesting case of acromegaly in the father, and infantile myxœdema in a child, is reported by Drs. F. M. Pope and Astley Clarke.†

The general enlargement of the bones of the hand is well shown. It is interesting to note that the epiphyses at the distal ends of the metacarpal appear to have escaped the hyperplasia.

Myositis Ossificans

An admirable review of the literature on this interesting subject, with full bibliography, has been given by Lydia M. De Witt, M.D., of Michigan.‡

Diagnosis of Œsophageal Diverticulum

Victor Blum records (*Wien. Klin. Woch.*, March 15, 1900) § a case where a diverticulum of the œsophagus was diagnosed, after œsophagoscopy had failed. The patient had been subject to obscure symptoms of œsophageal disturbance with eructation of food. A tube filled with mercury and closed at one end was introduced into the œsophagus, and arrested in its course before it reached the stomach; x-ray examination then showed the tube lying alongside the spine, about 10 inches below the level of the teeth, in such a fashion that a diverticulum was suggested. A sound filled with bismuth was then introduced with the aid of the fluoroscope, and the presence of the diverticulum made certain. On withdrawing the tube and sound it was possible to pass an indiarubber bag like a toy balloon filled with a solution of potassium bromide, which is opaque to x-rays, into the diverticulum, and in this way the exact position, form, and size of the latter was ascertained. Blum considers this the best method for actually diagnosing œsophageal diverticula.

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* *British Journal of Dental Science*, January 15, 1901.

† *British Medical Journal*, December 1, 1900, p. 1563.

‡ *American Journal of Medical Sciences*, September, 1900, p. 295.

§ *British Medical Journal*, Epitome, June 9, 1900, p. 90.

Aneurism

In discussing the diagnosis of aneurism by the Röntgen rays, Dr. Hugh Walsham* dwells on the value of the lateral oblique method introduced by M. Mignon of Nice. As all practical workers know, nothing definite is shown by a strictly lateral examination of the chest. By a three-quarter view, however, much may be learned as to the condition of the mediastina. On the screen may be seen in this way a triangular clear zone, which M. Mignon calls the retrocardiac triangle, bounded below by the convex shadow of the diaphragm, in front by that of the heart, and behind by that of the vertebral column. The last-mentioned or posterior boundary includes the shadows of aorta, vena cava, and œsophagus. There is another clear triangular space seen in front of the heart shadow corresponding to the anterior mediastinum.

'Tumours originating in the anterior mediastinum,' writes Dr. Walsham, 'can occasionally be well seen in this way. Any bulging of the vertical vertebral spinal shadow would indicate an aneurism springing from the thoracic aorta, or an œsophageal tumour, the rarity of the latter, however, making an aneurism probable. The anterior triangular clear space is seen readily enough, but the shadows in the retrocardiac triangle are more difficult; but I have seen this retrocardiac triangle filled up with shadow in a case of enlarged mediastinal glands.'

The necessity for caution in interpreting Röntgen ray examinations of the chest is shown by the following case, related by Kirchgaesser.† In a woman, aged seventy-five, the fluorescent screen revealed a dark shadow with expansile pulsation just above the heart shadow. Aneurism of the aorta was diagnosed, but post-mortem it was found that the aorta was firmly adherent to the œsophagus, owing to a carcinomatous growth, which arose from the cardiac end of the stomach. There was no aneurism, and the shadow thrown on the screen was probably due to the distension of the œsophagus with fluid.

* *Edinburgh Medical Journal*, April, 1901.
† *Münch. Med. Woch.*, May 8, p. 646.

Pneumothorax

A good x-ray illustration of pneumothorax has been published by Mr. Ernest Martin, M.B.,* of the City of London Hospital for Diseases of the Chest, by whose courtesy the block is here reproduced. The patient was a man, aged twenty-two, suffering from tuberculosis. Mr. Martin says: 'In a case such as the above there is, of course, no difficulty in making a diagnosis of the condition present, and the chief interest of the skiagram, apart from what may be learned from it by the practical x-ray worker, lies in the very clear demonstration of the position of the displaced viscera in a case where the lung is not firmly bound by adhesions, and when there is a positive pressure within the pleural cavity. The flattening and downward displacement of the diaphragm could hardly be made out by the physical signs; the position taken up by the lung, and the complete displacement of the heart from the left side of the chest, are all clearly shown in the diaphragm. Another point well brought out is the broadening of the intercostal spaces on the side of the pneumothorax. In addition, the skiagram shows the shadows thrown by the caseous tubercules, the

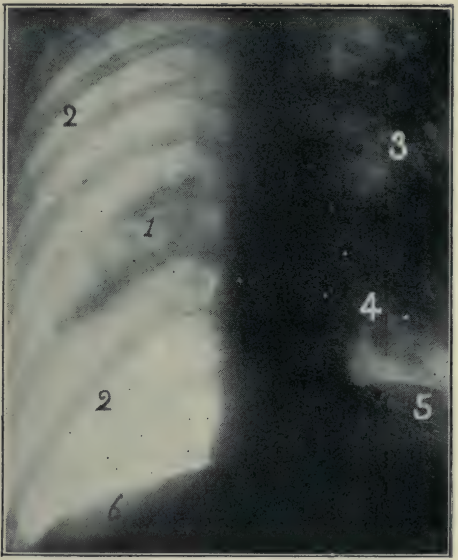

FIG. 109.—PNEUMOTHORAX.

1. Collapsed left lung. 2. Air in pleural cavity. 3. Tuberculous lung. 4 Right margin of heart. 5. Right dome of diaphragm, normal. 6. Depressed dome of diaphragm. (*Lancet.*)

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* *Lancet*, September 28, 1901.

portion of the lung immediately above the right arch of the diaphragm being the only clear piece of lung shown.'

Makrodactyly

Dr. W. Mafeig Jones* has published a case of this condition in a young man of twenty. A radiogram of the affected foot shows that the bones of the great toe were not enlarged, but that there was an exostosis on the inner head of the first metatarsal bone, and another on the base of the distal phalanx of the big toe. The fifth metatarsal was not enlarged, and the second only slightly; but the third and fourth were much hypertrophied, especially their distal ends. With the exception of the great toe, all the phalanges were enlarged, especially those of the third toe, and all showed exostoses.

Hæmophilia

Dr. F. J. Clendinnen† has published notes of a case, with accompanying radiogram, of hæmophilia. He was called to see a male child, eleven weeks old, for supposed injury to the right hip. On examination the hip was found to be much swollen, semiflexed on the abdomen, and painful. A radiogram showed the bones intact, but a general opacity in and around the joint, and the head of the femur separated from the base of the acetabular cavity. From the appearances thus presented, hæmorrhage into the joint was diagnosed. A few days later the child passed tarry motions. Two days later the left shoulder became swollen, and later the right. The rays showed that both elbows, which were not swollen, shared in the hæmophilic process. There was no family history of the complaint.

Joint Affections in Locomotor Ataxy

The pathology of this condition has been illustrated in a case reported by M. E. Dupré and A. Devaux.‡

A man aged fifty-four, under treatment for well-marked locomotor ataxy. In 1890 lightning pains occurred, varied by painless enlargement of both knees in 1897. The radiogram showed that the articular enlargement and deformity were due, not so much to lesion of the articular extremity of the bone, as to changes in their relations to each other, to synovial effusion, and to osteo-fibrous growths within the capsules of the joint. The femoral condyles of the knee-caps were normal, and the head of the left tibia alone was enlarged. On both sides the knee-cap was displaced forward, and the femur backwards.§

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* *Intercolonial Medical Journal of Australasia*, August 20, 1901, p. 389.

† *Quarterly Medical Journal*, February, 1900, p. 182.

‡ *Nouvelle Iconographie de la Salpêtrière*, September to October, p. 498.

§ For illustration see *Medical Review*, vol. iii., No. 26, November, 1900, p. 668.

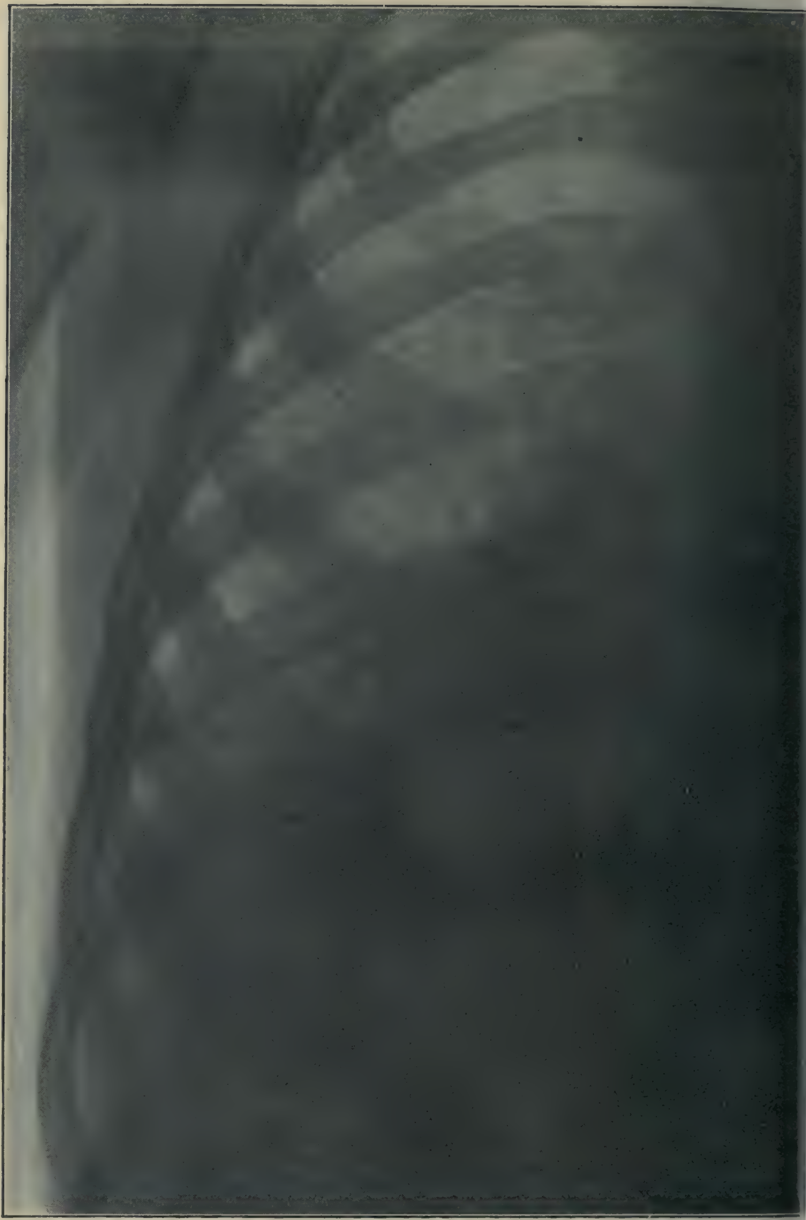
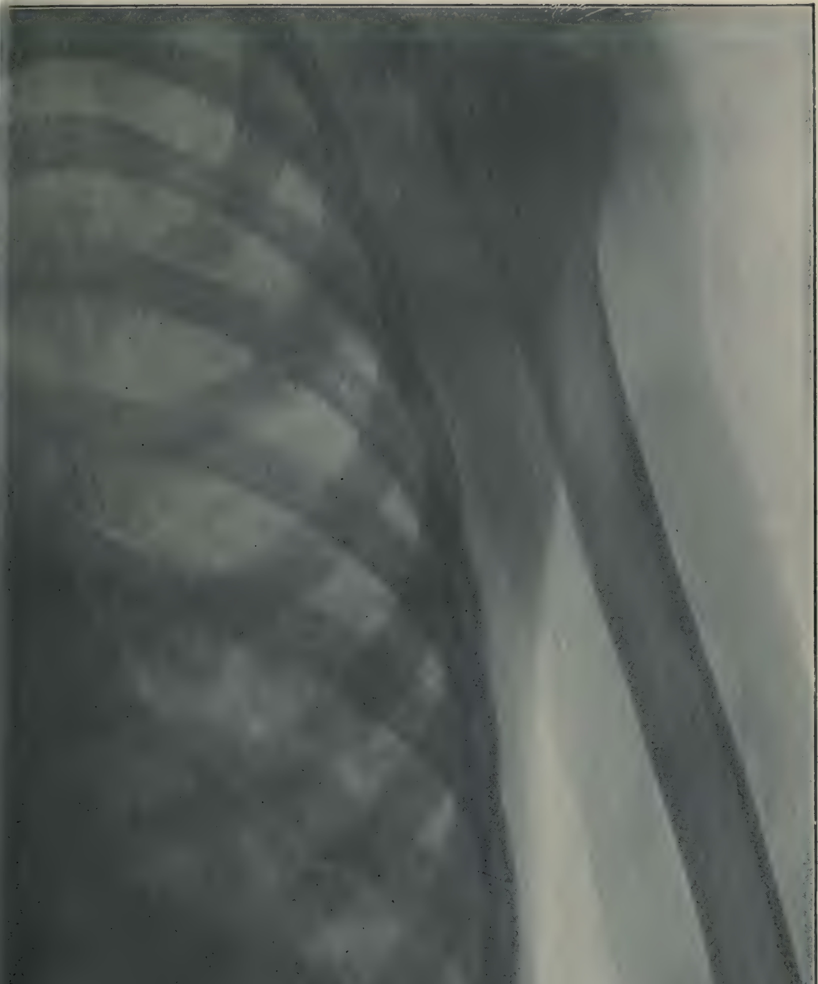


PLATE V.—THORAX S

(Plate reproduced by perm



D Miliary Tubercles.
ital. Taken by the Author.) [*To face p.* 282.

Gilbert has also shown that the bony swelling in such cases, which is believed to be extremely large, is really slight. The ligaments, tendons, and soft parts generally, are studded with bony islets, independent of each other, and separate from the articulation.

In the case above described, the inability to walk was due more to the joint affection than to ataxy itself.

Fluorescent Screen Blindness

It has been said that about 1 person in every 800 is blind to the Röntgen rays; that is to say, he is unable to distinguish the shadow-pictures on the fluorescent screen. This want of perception has been called Röntgen ray blindness. That term, however, is clearly a misnomer, as it is not the rays that the observer fails to see, but their effects. In all cases the faculty of distinguishing detail in screen shadows requires to be carefully cultivated. If an individual fail to see well-marked objects on the screen, it may be due to colour-blindness to the yellow shade of the ordinary screen. In that event it would be interesting to try if he were blind to a screen having a different tint of fluorescence. In estimating the degree of screen perception, the acuteness of the individual vision and visual errors (myopia, astigmatism, presbyopia, etc.) should be considered.

MEDICAL DIAGNOSIS BY RÖNTGEN RAYS

Specially contributed by A. W. Crane, M.D. (U. of M.), Kalamazoo, Michigan, U.S.A., Member of Röntgen Society, London

Thorax and Abdomen

For the purposes of medical diagnosis, soft tissues of small density must be studied. This demands x-rays generated by powerful currents in tubes of low vacuum.

The Thorax is a region singularly adapted to an x-ray examination. No other soft tissues of the body are distinguished by such differences in density as the thoracic viscera. The fluorescent screen is here incomparably superior to the dry plate, because the constant movements of the heart, lung tissues, and diaphragm, which serve only to blur outlines or erase details upon the plate, become factors of importance upon the screen. It is a great advantage to use a screen of sufficient size to receive the image of the entire chest. Relations, movements, and details of the shadow-image are thereby more accurately and quickly appreciated. All light must be excluded from the room, and the retina rested in darkness, or the most brilliant illumination of the screen will appear like a gas-jet in daytime. The stereoscopic fluoroscope is the ultimate ideal of clinical radioscopy.

Normal appearances must be familiar to one who would appreciate the radioscopic signs of disease upon the screen. The lungs are clear spaces which perceptibly darken and lighten with deep inspirations. This respiratory change is most marked in the lower half of the lungs. The pleuron is denoted by a delicate tracery of shadows following the outlines of the heart and great vessels. The diaphragm can be seen rising and falling with each breath. During quiet breathing it moves from 1 to 2 cm. The left side averages one interspace lower than the right.

The median line is marked by the broad shadow of the spinal column. To the lower left side, the shadow of the heart projects in bold relief, the apex lying at the middle of the left diaphragm, and the base lying at the middle point of the thorax. To the right, a narrow strip of the right ventricle and auricle may be seen. The contraction of the left ventricle with the peculiar retracting movement of the apex may be clearly observed. The pulsations of the right heart and of either auricle may also be distinguished. If the tube be placed at the level of the diaphragm, the clear pericardial space between apex and diaphragm may be seen during deep inspiration. The aortic arch and pulmonary vessels occupy the space between the base of the heart and the sternal end of the clavicles.

The heart is best studied from the front, and the great vessels from the back of the chest. It is often an advantage to turn the patient slowly around behind the screen, and to make a careful observation from the side with the patient's arms upraised. In pulmonary and pleural affections, the patient should be examined while lying down as well as while standing.

Appearances in disease result from two simple factors—shadow and motion. The relation of these factors to disease may be most clearly and compactly expressed in tabular form. See Charts I., II. and III.

An *x*-ray examination of the chest should be preceded by the ordinary physical examination. In that way the one will supplement and correct the other. But the information elicited by palpation, percussion, and auscultation is not in each case co-extensive with the information gained by the fluoroscope, skiameter,* and radiograph.

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* The skiameter is an instrument devised by the author to measure the intensity of shadows and linear distances. It is made of strips of tinfoil so graded as to give a scale of partial shadows. The principle applied is the obliteration of one partial shadow by another overlying shadow. It is fully described in the *Philadelphia Monthly Medical Journal* of March, 1899; also in the *Philadelphia Medical Journal* of January 6, 1900, vol v., No. 1.

CHART I.

- Lung and pleural sac
  - Increased transparency
    - General .. Bright or light reflex ..
      - Pneumothorax.
      - Emphysema.
      - Compensatory emphysema.
    - Local .. Bright or light reflex ..
      - Empty cavities.
      - Pneumothorax.
      - Bronchiectasis.
      - Local emphysema.
  - Decreased transparency
    - General ..
      - Light shadow .. ..
        - Generalized pleural thickening.
        - Congestion.
      - Dark shadow .. ..
        - Œdema.
        - Cirrhosis.
      - Black shadow .. ..
        - Effusion to apex.
        - Total consolidation.
    - Local ..
      - Light shadow .. ..
        - Infiltration.
        - Thickened pleura.
        - Atelectasis.
      - Dark shadow .. ..
        - Partial consolidation.
        - Small filled cavities.
        - Pleuritic exudates.
        - Small tumours.
        - Infarcts.
      - Black shadow .. ..
        - Consolidation.
        - Pleuritic effusions.
        - Gangrene.
        - Large filled abscess.
        - Large tumour.
        - Large hydatid cyst.
  - Motion ..
    - General .. Changes in density .. During respiration.
    - Local .. Changes in form ..
      - Of half-filled cavities.
      - Line of thickened pleura.
      - Effusions.

CHART II.

- Diaphragm
  - Visibility
    - Increased .. ..
      - Inspiration.
      - Emphysema.
      - Pneumothorax.
    - Decreased .. ..
      - Expiration.
      - Œdema.
      - Congestion of the lower lobe.
      - Consolidation of lower lobe.
      - Thickened pleura at base.
      - Pleuritic effusion or exudate.
  - Position
    - Low .. .. ..
      - Emphysema.
      - Asthma.
    - High .. ..
      - Cirrhosis.
      - Tuberculosis, etc.
    - (Difference of the two sides to be noted.)
  - Form .
    - Arched .. .. When high.
    - Flat .. .. .. When low.
    - Irregular .. ..
      - In diaphragmatic hernia.
      - Hepatic abscess beneath diaphragm.
    - (Difference of the two sides to be noted.)
  - Motion
    - Ordinary respiration
      - General range
        - Restricted ..
          - Tuberculosis, etc.
          - Pleurisy.
        - Exaggerated
          - Compensatory emphysema.
    - Forced respiration
      - General range
        - Restricted ..
          - Tuberculosis, etc.
          - Pleurisy.
        - Exaggerated
          - Compensatory emphysema.
      - Upper half
        - Restricted ..
          - Emphysema.
          - Asthma.
          - Pleurisy.
        - Exaggerated
          - Compensatory emphysema.
      - Lower half
        - Restricted ..
          - Tuberculosis, etc.
          - Pleurisy.
        - Exaggerated
          - Compensatory emphysema.

CHART III.

- Heart
  - Visibility
    - Increased
      - By deep inspiration.
      - By emphysema.
      - By cardiac hypertrophy.
      - By cardiac dilatation.
    - Decreased
      - By deep expiration.
      - By adjacent pulmonary shadows.
      - By œdema or congestion of lung.
      - By generalized thickening of pleura.
      - By empyema or effusion.
      - By very thick chest walls.
  - Displacement
    - To left
      - Cirrhosis of left lung.
      - Empyema or effusion on right side.
      - Tumour or aneurism on right side.
    - To right
      - Cirrhosis of right lung.
      - Empyema or effusion on left side.
      - Tumour or aneurism on left side.
    - Downward
      - Hypertrophy.
      - Aortic aneurism.
    - Transposition
      - Congenital.
  - Size
    - Increased
      - Hypertrophy.
      - Dilatation.
      - Pericardial effusion (apparent).
      - Cardiac aneurism.
    - Decreased
      - Senile atrophy.
      - Congenital lack of development.
  - Form
    - Irregular
      - Aneurism of auricle or ventricle.
      - Dilatation of single auricle or ventricle.
    - Rounded
      - Senile atrophy.
      - General dilatation.
      - Pericardial effusion.
  - Movements
    - Pulsation of auricles
      - Increased
        - Hypertrophy.
        - Auricular dilatation.
        - Auricular aneurism.
        - Valvular disease.
      - Decreased
        - Old age.
        - Debility.
    - Pulsation of ventricles
      - Apex beat
        - Increased
          - Hypertrophy.
          - Fevers.
          - Certain diseases and drugs.
        - Decreased
          - Dilatation.
          - Pericardial effusion.
      - Pulsation of right ventricle
        - Increased
          - Hypertrophy and dilatation of right ventricle.
        - Decreased
          - Senile atrophy.
          - Lack of development.
    - Heart reflex
      - Elicited by rubbing skin over heart by a blunt instrument.

By palpation we may feel the rhonchi, the friction fremitus, and the vocal fremitus. The rhonchi and the friction fremitus denote conditions which give no sign in radioscopy. The vocal fremitus is increased over consolidated areas, and decreased over emphysematous areas. In this it agrees exactly with radioscopic signs. If, however, we draw the conclusion that whenever the vocal fremitus is increased we should find an increased density in the fluoroscopic shadow, and *vice versâ*, we shall be disappointed. In pleuritic effusions we find the vocal fremitus decreased or absent, but we find the fluoroscopic shadow dense and unmistakable. The same is true of pleuritic thickenings, of filled cavities, and of consolidations with occlusion of the large bronchi. Moreover, the vocal fremitus is increased over dense-walled cavities, which would give a ringed area of light reflex upon the fluoroscopic screen. In these states it could be said that the results of palpation are not parallel with those of radioscopy. It is simply that the narrow limits of palpation must be kept in mind, and only its positive data considered.

Between percussion and radioscopy the comparison is closer. The same factors which determine the x-ray shadows also determine the character of the percussion-note. The results of percussion and radioscopy must agree, except that radioscopy is the more delicate and precise method. We may express the relations of percussion to radioscopy by a diagram :

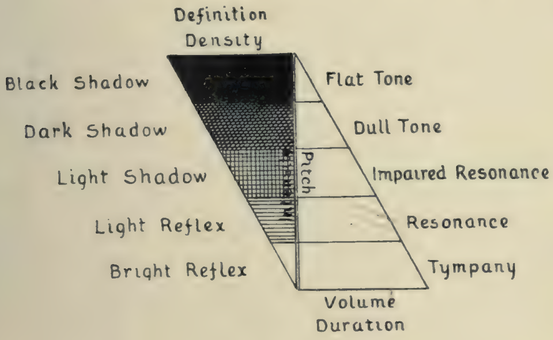

FIG. 110.

The field of auscultation is larger in many directions than that of pulmonary radioscopy. The sounds of the heart, affections of the bronchial tubes denoted by râles, and inflammations of the pleura denoted by friction sounds, are beyond the province of the x-rays.

Differential diagnosis in radioscopy is a matter of reflex, shadow, and motion. *A bright reflex* indicates a large, empty cavity or a large pneumothorax. If it be a cavity, the bright reflex may be centrally located and wholly surrounded by a dark or black shadow, or it may be peripherally located and only partly surrounded. The limits of a large cavity are never sharply marked unless on the lower side, when partly filled with sputum. If it be a pneumothorax, the bright reflex is peripherally located, and usually larger than in the case of cavity. If it exist without the presence of pulmonary shadows, the diagnosis is clear, because cavities are always associated with some consolidation. If, however, consolidation does occur with pneumothorax, the outline of the lung will be observable. A local pneumothorax from bronchial communication with the pleural sac, and from circumscribing adhesions, could not be distinguished from a peripheral cavity, especially if it occurred over the front or back area. Its position, however, front or back, could be determined by observing from which side it could be most plainly seen. The closer any object lies to the fluoroscopic screen the clearer the image.

A light reflex indicates a small cavity, a large cavity nearly full, a small pneumothorax, a greatly dilated bronchus, or an emphysema. If it be a small cavity, it will lie in the midst of a dark or black shadow, and may be called a light reflex, because it is in contrast with its surroundings. It may be encircled by a narrow ring of dark or black shadow if the walls are calcified. This is a healing process that can occur in a small cavity only. Why the calcareous thickening of a spherical cavity will cast the shadow of a ring is easily seen from Fig. 111. The x-rays traverse more substance in passing through the edges of the rim than in passing through the middle. This difference is the difference between the lengths *ab* and *cd*.

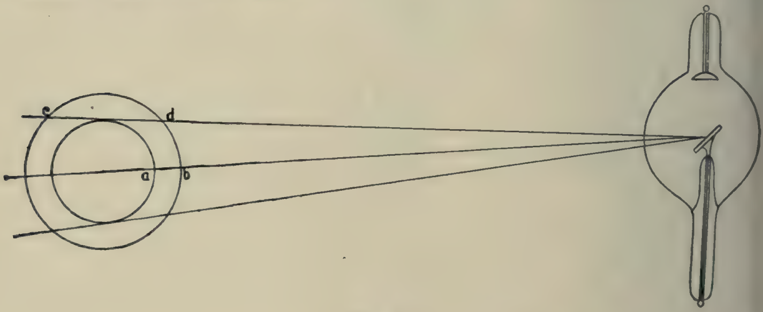

FIG. 111.

If it be a large cavity nearly full, the light reflex will rest upon a dark or black circumscribed shadow, unless the surrounding consolidation is so dense as to obscure the shadows of the mass of sputum. If the patient be re-examined on the table, the cavity may empty and become a large, bright reflex, or it may nearly disappear because the mass of sputum has come to lie in line with the empty space. If a faint reflex be observed without the presence of pulmonary shadows, it is likely due to a dilated tube in bronchiectasis. A dilated bronchus with consolidation could not be distinguished from a small cavity, unless a longitudinal form were to give a clue. A small pneumothorax, allowing a layer of air to surround the lung, would give a general light reflex, which would be indistinguishable from a true emphysema. In both cases the movements of the diaphragm would be restricted, its line low and its form flattened. But an emphysema is bilateral, unless there is some disease of one side to produce a compensatory condition on the other side. In the case of pneumothorax, the disease would be on the same side as the general light reflex. Hydro-pneumothorax or pyo-pneumothorax would give the same images as pneumothorax, except that we would have the dense shadows of effusions at the base. By changing the position of the patient, the relative position of the shadows and light reflexes would be changed.

A light shadow may mean an infiltration, a congestion, an atelectasis, or a thickened pleura. Between a tuberculous infiltration, a simple focal congestion, and an atelectatic area, there is no shadow-distinction. A thickening of the pleura may sometimes be differentiated from these three if its shadow be plainly visible, say from the front, and nearly or quite invisible from the back. But an infiltration or small consolidation lying close to one side would simulate this appearance.

A dark shadow indicates a partial consolidation, a small tumour, an infarct, or a cirrhosis. In the case of œdema the dark shadow is diffuse and of even density; a general cirrhotic lung would give a less even shadow, and would be accompanied by a marked displacement of the heart. Other physical conditions easily differentiate these two. A focal cirrhosis, an infarct, and a small tumour may give shadows of similar character, but a cirrhotic focus is most likely to be located in the apex, a tumour most likely near the hilum, and an infarct most likely in the periphery of the lung. A partial consolidation has very indefinite borders shading out into normal lung tissue. A small filled cavity is associated with some consolidation, and will appear as a dark spot in the midst of a dark shadow.

A black shadow may result from consolidation, gangrene, large filled abscesses or cavities, large tumours, large hydatid cysts, and pleuritic effusions. The last is distinguished by lying at the base of the thoracic cavity, by obscuring the diaphragm-line, by a more or less level upper border, and by being shifted when the patient's position is changed. The other conditions may not be separable by an x-ray examination, although their boundaries may be mapped out.

The diaphragm cannot be disregarded in radioscopy of the lungs. Its visibility, position, form, and motion are factors of the highest importance in estimating the extent and severity of a pulmonary disability. It is the vital barometer of the lungs, and may give the first signs of a coming storm.

Its visibility depends upon the contrast which its heavy shadow makes with the thin shadow of the lung. It is a dome of muscle which rests upon the liver on the right, and is visible across the whole extent. On the left it rests upon the stomach, and is visible across the outer half, the inner half being obstructed by the shadow of the heart. In forced inspiration, however, the diaphragm becomes also visible below the heart. The shadow-line of the diaphragm becomes more distinct in forced inspiration because the lungs contain more air and because the diaphragm, being flatter, interposes more tissue in the path of the rays. Conversely, the diaphragm-lines become less distinct in forced expiration, because the lungs contain less air, and because the diaphragmatic dome, being more arched, interposes less tissue in the path of the rays.

The diaphragm becomes very distinct when there is an emphysema or pneumothorax without effusion. But emphysema is either bilateral or else compensatory and attended by disease on the opposite side. On the other hand, pneumothorax would show the shadows of a partially or wholly collapsed lung. The diaphragm may become indistinct in œdema, hypostatic congestion, partial consolidation of the lower lobes, or thickened pleura around the base. But in œdema there is a general shadow of even density. In congestion, partial consolidation, and thickened pleura at the base, the upper areas of the lung may be normal. But these three are not separable on physical grounds alone.

The diaphragm becomes invisible when there is an effusion or a consolidation of the lower lobe. But with effusion the outline of the shadow may be easily shifted, and when the patient is placed upon the examining-table with the head lowered, the diaphragm comes into view. If the entire lung is consolidated, or if the effusion is encapsulated or reaches to the apex, the conditions may be indistinguishable without the use of the hypodermic needle. If the right lung is affected by tuberculosis, the diaphragm on that side will be higher than usual, while on the left it will be lower than usual, on account of the compensatory changes. In emphysema the diaphragm lies very low, in cirrhosis very high.

The position of the diaphragm largely determines the form. It is flattened when low, and arched when high. In diaphragmatic hernia the form is irregular.

The motion of the diaphragm is of great concern. We may recognise the range of movement in ordinary and in forced respiration. By marking the middle point in ordinary respiration, we may observe the upper and the lower half of a forced respiration. As a rule, in health, the range of ordinary and forced respiration is slightly greater on the right side than on the left. A restriction in the range of motion is a sign of some disablement. It is most likely to mean tuberculosis, pneumonia, or pleurisy. But it may mean almost any affection of the lungs or mediastinum. In true emphysema and pneumothorax, the respiratory movement is restricted in its upper half. In compensatory emphysema the respiratory movement is increased in both upper and lower half. This is important, because a compensatory emphysema on one side means an impairment of the lung on the opposite side. It may, however, in rare cases be an old trouble from which the patient has recovered. A very marked restriction in the motion of the diaphragm or its immobilization is a grave sign. Pleurisy, especially diaphragmatic pleurisy, forms an apparent exception. However, if the patient be encouraged, the diaphragm can be moved, although pain is the result.

When, in addition to the shadow-free lung, we find a natural movement of the diaphragm, we may feel assured that, even though tubercle bacilli are present in the sputum, the lung substance is not yet seriously affected. Such cases may be laryngeal or bronchial.

The heart may be outlined by the x-ray with a precision unequalled by any other method. Hypertrophy, dilatation or aneurism of either ventricle or of either auricle, may be perceived and measured. In pronounced cases of distension of the right ventricle, the apex may be tilted upward so that a space is left between the tip of the heart and the diaphragm. In dilatation involving the left ventricle, the apex beat becomes nearly indistinguishable. In rare cases a valve can be seen when it becomes calcified.

A vigorous cardiac reflex indicates a good tone of the heart muscle. This reflex is worthy of careful clinical study.

In examining the heart, keep in mind its visibility, position, size, form, and movements.

Pericarditis with effusion may be strikingly demonstrated by screen or dry plate. The pericardial space between heart and diaphragm is obliterated, even by a very small effusion. A large effusion will show the faint outline of the heart within a large ring. The distended pericardium gives a ringed appearance, for the same reason that a thick-walled cavity does, and, furthermore, for the reason that the pleura and lungs are pushed aside, thus forming a dense wall on the two sides, but not on front and back. An aspirating needle is clearly visible behind the screen, and may be accurately guided into the distended pericardial sac.

Aneurism of the thoracic aorta has afforded brilliant examples of the value of the x-ray. Aneurism is distinguished from mediastinal tumour chiefly by the presence of a pulsation. If this can be seen to be expansile the diagnosis is certain. But pulsations may be transmitted to tumours which lie against heart or aorta. The certainty with which long needles may be passed into an aneurism while in view beneath the fluorescent screen may aid in the treatment of this affection.

A calcification of the aortic wall may sometimes be delineated upon the dry plate.

The Abdominal Viscera vary from one another so slightly in density that differentiation by the x-ray is difficult and incomplete. But biliary calculi, and stones in the kidneys, ureters, and bladder, dermoid cysts containing bone or teeth, and the bones of a fœtus, may be successfully portrayed. Here, as in the thorax, the lowest vacuum tube which will give a good penetration must be used, so as to obtain the greatest possible contrast between tissues of small densities. The dry plate rather than the screen should usually be employed, excepting in the case of restless children. The stomach and bowels should be emptied, and then distended with gas and air respectively. The abdomen should be tightly bandaged to prevent the respiratory movements from blurring or erasing delicate details.

The stomach, in a thin abdomen, will show as a clear space with hazy outlines, below the left diaphragm. An hour-glass contraction may be perceived, and an enteroptosis may be distinguished from a simple dilatation. The distended stomach extends over the left border and half of the lower edge of the liver, and also over a portion of the outer border of the left kidney. The distended *cæcum* and ascending *colon* are usually very well marked, and overlie the outer border of the right kidney and a small portion of the lower edge of the liver. Thus, the *liver* is sometimes nearly outlined, and a small margin of each *kidney* may occasionally show upon the plate. The distended *rectum* and *sigmoid flexure* are not difficult to bring out, and the *psoas muscles* are nearly always visible upon a good plate. The ribs, vertebræ, and ilium offer no especial difficulties.

The fluorescent screen may be used to advantage in examining the stomach. If a patient, while standing behind the screen, will drink, in quick succession, a drachm each of potassium bicarbonate and tartaric acid, dissolved in separate glasses, the stomach may be beautifully demonstrated. Instead of distending the stomach with gas, an emulsion of the subnitrate of bismuth may be swallowed; or a stomach-tube containing a metallic chain or coil of wire may be passed and allowed to lie along the greater curvature; or a large capsule of bismuth subnitrate may be swallowed to mark the lowest point of the stomach. The latter may be used to good advantage in connection with the gaseous distension.

A. W. C.

MEDICO-LEGAL

Focus-tube Burns in Court

Since the publication of the second edition of the present volume towards the end of 1899, several important trials have taken place in which damages have been claimed for injuries due to Röntgen ray exposures.

In England a case was investigated at Hastings. The following account is taken from the *Lancet* of December 8, 1900, and its substantial accuracy is vouched for by the present author, who paid a special visit to Hastings in view of the importance of the issues involved. Speaking generally, it may be remarked that the trial impressed one with the necessity of expert help on both sides of an issue of the kind. It also shows the advantage of entrusting cases for Röntgen ray examination, wherever possible, to a medical operator who would be alive to any contingent risks, and who would share responsibility with the medical attendant.

'The recent case,' writes the *Lancet*, 'in which the Röntgen ray methods caused an injury preceding death, raises points of great practical importance to the medical profession as well as to non-medical operators with the rays and to the outside public. The following facts were deposed to before the coroner, Mr. Davenport Jones, at the adjourned inquiry held in the Hastings Town Hall on November 17, 1900.

'On March 21 last a widow lady, aged sixty-eight years, met with an accident to her left hip while learning to ride the bicycle. She was taken to the local hospital, where the opinion was expressed that no fracture existed. She was then removed home, and was attended by Mr. Harry R. Mansell, who could not make up his mind at the moment that the hip was fractured. After watching the case for some time he thought that it would be advisable to clear up matters by applying the Röntgen rays. This was done, with the consent of the deceased, by a local photographer, Mr. J. H. Blomfield, on April 14, when two exposures were made, according to the operator's statement, one of thirty-five and the other of forty-five minutes, each hip being taken separately. The result was not considered altogether satisfactory by the local medical society, and it was suggested a further photograph to show both hips should be taken from the centre of the body. This was accordingly done, with the consent of the deceased, on April 27 by the same photographer with an exposure of forty-five minutes. On both occasions Mr. Mansell attended and gave directions as to the position of the patient, but afterwards left the house and entrusted further details to the photographer. On the first occasion, according to Mr. Blomfield, the part of the body exposed was covered with clothing, but on the second it was bare. On May 4 an eruption developed on the left lower abdominal region. This was recognised by Mr. Mansell as an x-ray injury, and was treated with ointment, but the dermatitis developed into an ulcerated surface of the size of the hand. On July 5 the deceased declined further attendance from Mr. Mansell, and called in Dr. J. H. Roberts. The latter brought Mr. A. R. Ticehurst in consultation, and attended the deceased until her death on November 5. On July 7 Dr. Roberts found her to be suffering from a sloughing wound about 7 inches by $3\frac{1}{4}$ inches. Death, in his opinion, was caused by exhaustion from the effects of shock, which resulted from two injuries—the fracture of the thigh and the action of the Röntgen rays. Mr. Ticehurst, who visited the deceased in consultation, and who subsequently performed a post-mortem examination, stated that when he saw the deceased alive on October 5 he found her to be suffering from a dry sloughing wound of the abdomen. At the necropsy the wound had lost its slough, but there was little sign of repair. There was little fat about the body, the heart was flabby, the stomach was empty, the liver showed signs of old mischief, the vessels were degenerated, and he found an impacted, intracapsular fracture of the neck of the femur. Mr. Ticehurst would not say that the condition of the body would be sufficient to cause death apart from the wound. The niece of the deceased stated that her aunt's mind gave way several weeks before her death, and she refused food, which had to be forced upon her by the nurses. The photographer, Mr. Blomfield, stated that he had had four or five years' experience with the rays, part of the time at the Hastings Hospital, and had met with no injurious effects from similar prolonged exposures. Dr. Lewis Jones, in charge of the electrical department of St. Bartholomew's Hospital, gave evidence to the effect that he had seen the apparatus used by Mr. Blomfield to take the photograph of deceased. There being no rash between the first and second exposures, he would consider a medical man right in assuming that the patient was not sensitive to the rays. The risk of an *x*-ray burn was always present in long exposures. The apparatus used by Mr. Blomfield was a year and a half out of date. In default of a better instrument, the one used was a proper one. It gave a 10-inch spark, and a similar one was in use at St. Bartholomew's Hospital until a year and a half ago. He himself had given exposures of forty minutes, but the usual length of time was seven or eight minutes. Short exposures were less likely to cause burns than long. At the time when the photograph was taken Mr. Blomfield's coil was working at $5\frac{1}{2}$ inches. The coroner summed up, and the jury returned a unanimous verdict: "That the deceased met her death from shock and exhaustion following the accident and the effects of the Röntgen rays upon a weakened system. No blame attached to either the medical man or the photographer."

'With regard to this case, it may be remarked that the fact of the friends of the deceased not having been represented by expert evidence detracts somewhat from the value of the inquiry. It was admitted that no note was made of the time of the exposure, the distance of the tube from the plate, and other details that cannot safely be left to the memory.

From the evidence it is clear that a burn resulted from prolonged exposure to the focus tube, probably from the third exposure of forty-five minutes on April 27, as the rash appeared seven days after that date. However, the fact that the first exposures were not followed by dermatitis during the thirteen days that elapsed does not absolve those exposures from all blame. It is reasonable to assume that the degenerative changes in the body of the deceased were indirect factors in the causation of the burn just as they were in the fracture of the hip.

'Unfortunately, for reasons already stated, the full details of the exposures are not available. At the same time we are told of one important differing condition of experiment—namely, that the surface of the body was not protected by clothing on the third exposure, the one from which the damage in all probability resulted. No mention was made of the crucial point of the distance of the focus-tube from the skin. Nor was the fact made clear to the court that a 10-inch coil working at 5½ inches is reduced almost, if not quite, to the lesser value. The bearing of this upon the length of exposure is obvious. With his coil working at 10 inches Mr. Blomfield could have almost halved his exposures, and the focus-tube burn is distinctly related to the length of exposure. The reasons for a coil not working up to its full strength are various, but all are open to remedy. The mention of these facts will show the desirability of having expert evidence on both sides of so highly technical an inquiry.

'As regards the responsibility of a medical man who engages a non-medical man to take a Röntgen photograph, the matter is not advanced by this case. The fact that the patient consents to the photography can hardly absolve the medical attendant. If the latter hands over the operation to a non-medical man, it is a question of how far he is relieved of responsibility. A chemist is responsible for errors in dispensing a prescription, but he is licensed to practise pharmacy, whereas the electrical or photographic worker with the rays has no such recognised and tested legal status. If the non-medical photographer had undertaken the case for the local hospital, what would have been the position of the committee of that institution in the matter? On the other hand, the employment of a medical Röntgen ray expert would clearly absolve a medical man of further responsibility. Any medical operator must have hesitated to expose to the rays for forty-five minutes an old lady who had been laid up for five or six weeks with a broken hip. It seems undesirable, moreover, that female patients should be submitted to the manipulation of instrument-makers and other non-medical workers with the rays. The moral of the case appears to be that apparatus should be up-to-date, and that medical men will act wisely in sending their cases to medical Röntgen ray experts, of whom there are a fair number available.'

In the United States a suit was brought for $25,000 damages against

Dr. Otto Smith and Professor W. C. Fuchs of Chicago. A summary of the case appears in the *American X-Ray Journal.*[*]

The plaintiff, aged thirty-seven, broke his right ankle as the result of an accident from his buggy on September 2, 1895. He was able to attend to his lumber office and yard by May 1, 1896, and was then practically as well as before the mishap. He suffered, however, from slight stiffness and occasional swelling in the ankle. On September 19, 1896, '*x*-ray photographs were made'—the exact number not stated—'occupying from thirty-five to forty minutes, by placing the tube from 5 to 6 inches from the ankle, the tube being about the same distance from the top of the foot.' While under the exposure he experienced and complained of sharp, tingling pains. Three days after a slight redness appeared between the big toe and the first toe, which in three weeks had spread to almost the entire surface of the top of the foot, and later formed a blister. An ugly-looking and intensely painful ulcer formed, for which condition amputation of the foot was performed. The jury awarded $10,000 damages.

In France an important trial heard before the Civil Tribunal of the Seine on March 8, 1901, resulted in heavy damages for injury following the application of the Röntgen rays.[†] In delivering judgment the court found that Madame Macquaire, who suffered from osteitis of the femur, was handed over early in 1898 by Dr. Rousseau to Dr. Renault, in order that the latter might make a Röntgen ray examination. Three exposures were made: the first of forty minutes, the second of forty-five minutes eight days later, and the third of an hour and a quarter fifteen days after the second. A slight erythema was noticed before the third sitting. The three exposures, which were negative as regards diagnosis, were followed by a deep burn of the abdomen that necessitated treatment for upwards of two years. A scientific report of the case was presented to the court by Professor Brouardel. Among other things, he concluded that the operator had an apparatus which was formerly good, but had become bad, and that he had given too long an exposure. The court, commenting on the defective methods employed, observed that the defendant was called in, not as a medical man, but as an electrical specialist, but that, nevertheless, his medical title had gained the confidence of his clients against bad results. A too long exposure was certainly one cause of the accident. The third exposure of an hour and a quarter was inexcusable (*inadmissible*), in view of the fact that the tissues had been already injured by a previous exposure of a little over half that time. The conclusion of the court was that Dr. Renault had committed a grave professional error, and he was ordered to pay damages to the extent of 5,000 francs.

An interesting case[‡] tried in Providence, R.I., emphasizes the value of experienced medical testimony either in supporting or in rebutting evidence based upon Röntgen ray photographs. The plaintiff, a woman, brought an action for $4,000 damages. Two years before she sustained an injury of the wrist, which was treated as a Colles' fracture. At the time it was held by some of the medical men consulted that the injury was a Barton's fracture—that is to say, an oblique fracture of the radius extending from the joint. Radiograms were produced on both sides. Those of the plaintiff showed a characteristic deviation of the hand to the radial side, but the defendant contended that this deformity was assumed for the purpose of deception. For the defendant, Dr. Green said that about 1 inch from the carpal end of the radius there were slight prominences extending laterally from the shaft of the bone, a point corresponding to the site of Colles' fracture. According to his evidence Barton's fracture was not confirmed by the *x*-rays. Adopting that view, the court dismissed the case.

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[*] *American X-Ray Journal*, St. Louis, Mo., May, 1899, No. 5, p. 566.

[†] See *Gazette des Tribuneaux*, March 9, 1901; and *La Semaine Médicale*, March 13, 1901, p. xlii.

[‡] *American X-Ray Journal*, May, 1899, No. 5, p. 568.

In commenting upon the foregoing trial, the editor of the *American X-Ray Journal* remarks that from the report of the case it is not possible to resist the feeling that the evidence was insufficient to prove a Colles' fracture, and lacking in *x*-ray expert testimony to disprove a Barton's fracture.

'The report of this case,' he writes, 'does not read as if the evidence was all brought out. In the *x*-ray examination the writer would judge that the radiograms of the hands were taken in opposite directions on the same plate. It is a well-known fact that the right and left hand and forearm laid evenly and opposed will not show corresponding space between the bones of the carpus and the radius. If the physician understands anatomy and radiography very well, he can at will distort a normal joint in a picture, or favourably present the condition of an injured one. The normal divergence of the *x*-rays, which is constant always to some degree, makes the picture untrue. The distortion by position can be of almost any degree, and with an operator who is an expert we must rely on his oath. If he is not an expert, his testimony is faulty. It was not shown in this case that *any means were taken to obtain parallelism of the x-rays*.'

Action for Malpraxis

A Miss Jameson of Great Works, Me., claimed damages against Dr. G. G. Weld, of Old Town, for $4,000 damages on account of alleged malpractice in setting her dislocated right elbow.*

The plaintiff, after an accident, was attended by Dr. Weld, who called two other medical men in consultation. After some days, as treatment afforded no relief, the patient suggested the use of the Röntgen rays. Dr. Weld, according to plaintiff's testimony, declined because he knew the nature of the injury—namely, a fracture of the olecranon, fracture of both condyles, and dislocation. The patient went to a hospital, and a Röntgen ray photograph, admitted in evidence, revealed no fracture, but a backward dislocation, which was successfully reduced. The x-ray picture was the conclusive factor in this case, for it showed the condition of the arm at the close of the defendant's treatment. The jury found a verdict for plaintiff.

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* *American X-Ray Journal*, May, 1899, p. 569.

Malingering

Dr. Baehren of Wiesbaden published the case of a soldier who was treated for a swollen finger and sinus of the third metacarpo-phalangeal joint. On x-ray examination five needles were seen in the interosseous space, but next day only four. The man afterwards admitted he had introduced the needles himself in order to escape military service.

Life Insurance

Mr. F. H. Williams* has pointed out the value of the rays in life insurance examinations—at any rate, so far as concerns abnormal conditions of the chest. It may be added that a negative result might enable a rejected applicant, or one who had been highly rated, to dispute the decision.

Copyright in Radiograms

A medical man wrote to the *Lancet*† complaining that he had sent a patient to have a radiogram taken by an instrument-maker, who had afterwards, without his sanction, supplied a copy to another person, and sent a representative to a public meeting to explain the plate. The *Lancet*, commenting upon this occurrence, expressed a strong opinion upon this breach of trust in using a radiogram without obtaining the leave of the patient and the medical man. In a later issue of the same journal‡ Dr. Major Greenwood said there was little doubt that a man who takes a radiogram for a customer is acting illegally if he makes any use of it contrary to the wish of that customer, and could be restrained at law from so doing. That was decided in 1899 in the case of Pollard *v.* Photographic Co. (40 Ch. D., 345), where it was held that a photographer may not sell, or exhibit, or otherwise deal with, the photographic negative of a private person who has employed him to take a photograph. That decision would clearly apply to the case of a radiographer.

Fallacies

Many fallacies may arise from an unusual relative position of the focus tube towards the part under examination. By shifting a limb up and down and from side to side, its shape upon the screen may be distorted so as to resemble a variety of deformities. It is well in all cases of supposed injury to make a routine examination of the correspondingly sound side of the body under exactly similar conditions as to relative position of parts and of focus tube.

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* *Boston Medical and Surgical Journal*, December 28, 1899.

† November 4, 1899, p. 1274.

‡ November 11, 1899, p. 1343.

Flaws in the sensitive plate or in its development may sometimes lead to an error; and when *x*-ray paper is used, a small crease or inequality of surface may result in a perplexing record.

Buttons, coins, or other objects about the person of the patient may cause confusion.

Seiz has pointed out the mistakes that may arise from a misinterpretation of the results of the fluorescent screen. In one case an outward dislocation of both bones of the forearm took place in a girl of thirteen. A radiogram taken twelve days after reduction showed a normal position of joint, but an apparent separation of the tip of the olecranon, of which, however, there was no trace to be found on clinical examination. In a second case the *x*-ray photograph showed what appeared to be a shortening of 3 inches in a fracture of the femur, whereas the clinical measurements proved there was not more than 1 inch of shortening. As Seiz points out, such false impressions might now and then have the greatest importance, especially in actions for damages.

Callus may be pervious to the rays some months after a fracture, and may thus give an impression that there is non-union, whereas the parts may be firmly united.

A fracture without displacement may not show on the *x*-ray photograph, but may often be recognised when viewed from a fresh aspect. Hence it is well to examine first with a screen, so as to determine on the best position for securing an effective record.

It should be borne in mind that in fractures where there is little or no displacement the radiographic evidence may be either slight or altogether absent. The fracture-line of the picture, again, may be obliterated within four to eight or ten weeks by the ossification of the callus. In old fractures there is no fracture-line, but the injury may in many cases be inferred from bony irregularities. Where there is either imperfect ossification of callus or fibrous union of fragments, as in the olecranon, the fracture may be permanently recognisable by Röntgen methods.

Shepherd* first pointed out, as the result of an experience of his own, that the os trigonum tarsi, or intermedium cruris, could be mistaken for a fragment broken from the astragalus. This bone, which is said to persist in about seven or eight per cent. of the human species, forms a typical part of the mammalian tarsus. In his excellent book on fractures, Dr. Carl Beck† of New York has brought together the following interesting account of this abnormality:

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* 'A Hitherto Undescribed Fracture of the Astragalus.' *Journal of Anatomy and Physiology*, October, 1882.

† 'Fractures,' Carl Beck, M.D. Saunders and Co., Philadelphia, 1900.

'The fact that this fracture is not mentioned in any of the text-books of surgery or in special treatises on fractures would easily be accounted for by its only being discovered by dissection; it causes no deformity, and the symptoms it would give rise to during life would be obscure. Shepherd tried to produce this fracture artificially on the cadaver, but "in every case," he says, "where this manœuvre was performed, I failed, even when the greatest force was used, to break off the little fragment of bone mentioned above."

'Pfitzner* regards the os trigonum tarsi as an integral part of the posterior process of the astragalus in the adult, which is analogous to the os intermedium antibrachii.

'The practical significance of this bone is evident from a case described by Wilmans,† which is also highly interesting from a medico-legal standpoint:

'A labourer claimed that he was injured by an iron bar on January 20, 1897, but was able to work during the whole day. On the following day he called upon Dr. Wilmans, complaining of intense pain in his internal malleolus. He limped, and asserted his inability to work. Wilmans found a slight swelling below the right internal malleolus. Ecchymosis of the skin being absent, the swelling was attributed to the presence of a considerable degree of talipes, from which the labourer suffered at the same time. The leg was elevated, and fomentations were applied for several days. The labourer still complaining of great pain, it was decided to transfer him to a hospital for observation. When discharged after several weeks of treatment, the labourer made an effort to resume work, but at once declared that he was unable to keep it up. He was therefore admitted to another hospital, where he repeated this manœuvre several times during a period of six months. Finally, he claimed damages for having been crippled by the injury sustained on January 20, 1897; but in view of the negative objective condition found by Dr. Wilmans the society decided not to grant any claims. The consequence was that the labourer was transferred to the surgical division of a third hospital for further observation. There he complained that he had continuous pains below the right external malleolus, even while in the recumbent position. The pain increased while walking or sitting. Stepping on the right heel he also declared to be impossible. By distracting his attention, however, it was noticed that he could stand well on his heel, and he would undoubtedly have been declared a malingerer had not the Röntgen rays come to his rescue—at least, temporarily. A skiagraph showed a bone fragment at the junction of the astragalus with the posterior surface of the calcaneum. On the strength of this skiagraphic "proof," Dr. Wilmans, although still mistrusting, was forced to modify his original opinion, and certified that the patient suffered from "fracture of the astragalus, in consequence of which he was damaged for life." The labourer therefore received an annuity of 30 per cent. in proportion to the estimated curtailing of his wages.

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* 'Beiträge zur Kenntniss des menschlichen Extremitaätenskelets, morphologische Arbeiten,' 1896, 2 tes Heft.

† *Fortschritte auf dem Gebiete der Röntgenstrahlen,* Band ii., Heft 3.

'Soon afterward the labourer was discovered by Dr. Wilmans carrying a heavy weight without any apparent pain, while formerly he had claimed to be unable to walk without a cane or a crutch. Dr. Wilmans insisted upon a second irradiation, this time also skiagraphing the uninjured left foot. The skiagraph showed the "severed bone fragment," which had first been regarded as a sesamoid of the musculus flexor longus hallucis, but which was now recognised as a normal os intermedium cruris. The society of course refused the annuity, and the German Supreme Assurance Court, to which the labourer had appealed, not only sustained the verdict of the society, but also decided that the labourer must return the annuity which he had unjustifiably enjoyed for eighteen months.'

It may be noted, with regard to the above interesting case, that surgeon, society, and court all appeared to have attached an exclusive and conclusive value to fracture. Clearly, bone disease resulting from injury and damage to soft parts would not be shown by the rays except as an extremely rare occurrence.

Mr. C. H. Golding Bird* has pointed out some of the fallacies of radiography in relation to fractures. While deprecating the use of the x-rays in all fractures, he advocates their use when the surgeon requires more exact information in any particular case, and where the nature of the injury is doubtful. The second class includes those of the fibula, vertical and transverse fractures in any situation, and certain fractures about the hip. He urges that radiography should be regarded as a subsidiary agent to diagnosis, and its evidence in cases of doubt and difficulty should be received *with caution, and only after due interpretation by someone whose experience warrants his speaking with authority.*

In answer to the question whether the rays can show a fracture where none exists, he mentions:

1. Epiphyseal lines—*e.g.*, lower end of ulna.
2. The light interval of a joint—*e.g.*, elbow over olecranon.
3. Acromio-clavicular joint resembling fracture.

THERAPEUTICS

Rodent Ulcer, Cancer, and other Skin Troubles

Stembeck† of Stockholm reports the cure of rodent ulcer on the nose of a woman aged sixty-seven. The sittings took place daily with an exposure of ten to twelve minutes. After the thirty-fifth application improvement took place, and ultimately the ulcer healed, its position being shown by a smooth covering differing only slightly from the neighbouring skin.

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* *British Medical Journal*, June 8, 1901, p. 1390.

† *Hygeia*, Stockholm, 1900, p. 18. *Mittheilungen aus d. Greuzgebeite d. Med. und Chir.*, Bd. vi., No. 3.

Rodent ulcer has also been successfully treated by focus-tube exposure. Dr. J. H. Sequeira* reported twelve cases, in three of which the ulcer healed, eight were in course of healing, and one gave up treatment, so that in no instance was there a disappointing result. He was led to try the Röntgen method upon a patient who suffered from a severe rodent ulcer, but who could not bear the pressure of the special apparatus used in the Finsen light treatment. As the result of his experiments, he feels justified in recommending the use of the x-rays—at least, in cases where complete removal by the knife is impracticable.

Mr. Andrew Clark † has published a case in which a large ulcerating carcinomatous surface involving the whole of the right breast cicatrized under several months' use of the focus tube. The woman was sixty years of age, a sister had died of cancer, she had some syphilitic ulcers on legs, and was treated with iodides while undergoing the x-ray treatment. Some enlarged glands in the axilla decreased in size.

The cure of epithelioma by focus-tube exposure has been reported from various quarters. Dr. F. H. Williams, of Boston, has treated eleven cases of flat epithelioma of the face with excellent results.

Mr. L. H. Harris, M.B.,‡ of Sydney, has recorded an interesting case of removal of hypertrophied scar tissue by the Röntgen method.

The patient was a young woman who showed a somewhat extensive scar fifteen months after the removal of some tuberculous glands. After thirty-two sittings the hypertrophied scar, which had been ½ inch thick in some places, disappeared, leaving only the mark of the original skin incision.

The cure of a port-wine stain has been reported by Jutassy. The whole of the right side of the face was affected, and treatment involved a severe dermatitis, which took two months to heal, leaving a smooth white scar.

Relief of Pain by the Rays

Stembo claims to have cured a number of cases of neuralgia.§ He admits that the rays act partly by suggestion, but states that when the anodal rays are substituted for the kathodal, without the patient's knowledge, no analgesic effect is obtained. Relief was usually obtained in three applications, but if ten applications brought no relief the treatment was abandoned.

Stembo has used the rays for the relief of pain in thirty-seven cases. In twenty-eight it was carried out thoroughly, and twenty-one were cured of various neuralgias, such as trifacial, occipital, cervico-brachial, intercostal, visceral, and sciatic. He was led to employ the rays as an analgesic because patients who had been examined for diagnostic purposes remarked they had been relieved of pain. He used an apparatus with a spark of from 12 to 18 inches, and about 1,500 interruptions per minute. The distance of the antikathode from the part varied from 8 to 20 inches. The unaffected part was protected by tinfoil. Sittings were made every other day, and lasted from three to ten minutes. Stembo thinks it essential that, on gently touching with the tips of the fingers the part of the body to which the rays are being directed, a slight pricking sensation should be felt.

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* *British Medical Journal*, February 9, 1901, p. 332.

† *Ibid.*, June 8, 1901.

‡ *Australasian Medical Gazette*, April 20, 1901.

§ *Therapie d. Gegenwart.*, June, 1900, p. 250.

Sokonow of St. Petersburg has applied the focus tube in four cases of articular rheumatism in children, and states that he has obtained good results.

Favus

Norman Walker* has reported favus successfully treated.

Alopecia Areata

Herr M. R. Kienböck showed a man, twenty-six years of age, suffering from alopecia areata of several years' duration. The Röntgen rays were applied to one particular area, and after six applications of a quarter of an hour each a growth of hair was observed.

Depilation

Some people claim success with repeated short exposures—ten minutes. Dermatitis seems to occur now and then, however, in the most skilful hands.

Dr. Neville Wood† applied the focus tube to a woman aged twenty-two, who had considerable overgrowth of hair on the face. Eight months after the cessation of treatment the thick down and hair had not returned upon the chin, but there was a downy growth on the cheeks.

The exposures were of ten minutes' duration applied six times a week, and were attended with one sharp attack of dermatitis. He surmises that ten short exposures are useless; that about twenty will clear the ground for electrolysis, or simple traction, if the ray treatment has to be suspended; whilst between thirty and forty will probably produce permanent destruction of the hairs.

Freund‡ says that after depilation by the focus tube the hair grows again after two months. By applying the rays, however, three or four times every six weeks, he says that it is possible to keep the face permanently hairless. He reports smooth scars nearly resembling normal skin in lupus vulgaris and lupus erythematosus. He also speaks favourably of this method of depilation in sycosis favus and ordinary ringworm.

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* *Lancet*, June 6, 1900.

† *Ibid.*, January 7, 1900, p. 231.

‡ *Wien. Klin. Woch.*, September 28, 1899, p. 966.

In one case, reported by Messrs. Barthelemy and Darien, the hairs grew again, after a period of eighteen months, in a guinea-pig which had been depilated by a prolonged exposure to the focus tube.

The description of the following method of depilation is reprinted from the author's paper in the *Lancet* :*

THE REMOVAL OF SUPERFLUOUS HAIR BY A COMBINATION OF X-RAY EXPOSURE AND ELECTROLYSIS.

By David Walsh, M.D. Edin., Honorary Physician Western Skin Hospital, London, W.

There are few cosmetic operations more desirable from the feminine point of view than the removal of superfluous hairs from the face and other parts of the body. Short of operation various methods are in vogue, such as pulling out the hairs, shaving, and the use of depilatories. None of these plans, however, get at the root of the mischief, while they act more or less as local irritants that, by stimulating the supply of blood to the part, actually increase the growth of the hair. Depilatories destroy the shaft of the hair, but they do not touch the hair-bulb. They have been used from time immemorial, but their application would hardly be sanctioned by the modern dermatologist. Some women rub the skin smooth with pumice-stone ; others prefer shaving with a safety razor—a plan that is, perhaps, to be approved when there is a thick downy growth of hairs too numerous to be removed by electrolysis.

The latest method of depilation before the profession is that effected by the x-rays. Within nine months of the announcement of Professor Röntgen's discovery there were reported several cases of dermatitis, to which I ventured to give the name of 'focus-tube dermatitis' in July, 1897.†

The earliest note of shedding of hair which I have found recorded was by Mr. E. E. King, of Toronto.‡ Since then many instances have been recorded, notably one by Professor Waymouth Reid, who lost the hair of the chest and face after four consecutive daily exposures of the trunk for twenty, forty, fifty, and ninety minutes respectively.§ Before long the Röntgen rays—or, rather, exposures to the focus tube—were applied for the depilation of hair. In at least one instance that came under my notice severe and extensive sloughing was caused by the exposure of a chin to the live tube. After a little time it was found that a short exposure of ten or fifteen minutes with the tube a few inches only from the surface of the skin affected the nutrition of the hair to such an extent that the hair became loose and fell out within a week or ten days of the exposure. The hair-bulbs, however, were clearly not destroyed, as the hairs were quickly reproduced. In one case reported by M. Barthelemy and M. Darien the hairs grew again in a guinea-pig that had been depilated eighteen months previously by a prolonged exposure to the focus tube. Freund finds that the hair grows again on the face two months after depilation by that method.* By applying the rays, however, three or four times every six weeks it is possible, he says, to keep the face permanently hairless. Schiff has also worked on much the same lines. It is evident that any method depending on such repeated applications must be extremely tedious, and no results have hitherto been published which justify absolute success for any plan of the kind. At the same time, the application of the focus tube has to be made by skilled and cautious hands, otherwise the results may be disastrous. For one thing, it is certain that the idiosyncrasies of individual patients differ greatly so far as the resulting dermatitis is concerned. Indeed, from my own observations it seemed to me long ago that the susceptibility of the individual worker might vary from day to day. The ideal exposure in depilation is that which suffices to cause the shedding of the hair with little or no apparent erythema or dermatitis. The part of the face around the area to be cleared should be protected with a mask of lead-foil. The drawbacks of depilation by the focus tube, then, are the risk of dermatitis (a small one under modern methods and in skilled hands) and, above all, the regrowth of the hair.

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* *Lancet*, November 2, 1901.

† Transactions of the Dermatological Society of Great Britain and Ireland, vol. iii., p. 13.

‡ *British Journal of Dermatology*, January, 1897.

§ D. Walsh : 'The Röntgen Rays in Medical Work.' London, second edition, p. 205.

Electrolysis, on the other hand, is an effectual but tedious agent. It can hardly be applied in cases where there is a thick, close growth of hair, as each bulb has to be destroyed by the electrolysis-needle. In the hands of the most skilful operator it is not always possible to guide the needle in the direction of the hair-follicle. Fortunately, from experiments conducted by Giovannini,† it appears that destruction of the papilla may follow, even though the needle has pierced the wall of the hair-sac and cauterized the surrounding tissues. There is no need here to describe the details of this small operation. The needle is connected with the negative pole of a battery yielding from 1 to 1·5 milliampères, and the circuit is completed by pressing a sponge electrode saturated with warm salt water against the patient's skin. The circuit should not be completed until after the needle is inserted into the hair-follicle, and the current should be broken before the needle is removed. The operator must insert the needle as nearly as possible in the direction of the hair-follicle. It should be kept in place for twenty or thirty seconds until little bubbles of gas appear at the point of insertion. After the removal of the needle, if the operation has been successful, the hair can be removed with gentle traction by a pair of forceps. The painfulness of the method forms one of the chief objections to electrolysis, and it varies much with the individual. No matter how skilfully performed, there will be recurrence of growth in a certain percentage of hair-follicles. To those who have the requisite patience and resolution, however, it offers the best chance of permanent removal of superfluous hairs.

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* *Wiener Klinische Wochenschrift*, September 28, 1899, p. 966.

† *Archiv für Dermatologie und Syphilis*, August, 1895.

Some time since it occurred to me that a combination of the two methods of focus-tube exposure and electrolysis might be of advantage. I have found the following method useful where the growth is not too thick. The exposure to the focus tube is made in the ordinary way, and a week or ten days later, when the hair becomes loose, each hair is extracted and the electrolysis-needle is passed into the follicle. This method means that a large number of electrolytic punctures must be made in a small area. However, with a little management the removal may be made to extend over a couple of days, and in that way it is possible to remove, so to speak, alternate hairs. Sometimes several exposures to the focus tube are needed before the hairs become loosened.

This combined method I have found useful in some cases, as it increases the chances of effectual cauterization of the emptied hair-follicle. At the same time it shortens the period of depilation, but, like pure electrolysis, it should not be undertaken unless the patient has enough resolution and patience to undergo the requisite treatment.

Drs. T. Sjögren and G. Sederholm,* of Stockholm, have published a series of cases of various kinds treated with the focus tube. They are inclined to attribute the therapeutic action to the invisible *x*-rays, while the ultra-violet rays mixed with them have little to do with the beneficial effects. The authors were disappointed with results in twenty-seven cases of lupus vulgaris on account of the resistance of the lupus nodules. Recurrences were about equal to those met with in patients treated by other methods. Lupus erythematosus required considerable reaction, but was successful in the long-run, and the same remark applied to tuberculides or scrofuloderma. Results were excellent in chronic eczema, pruritus, in two chronic ulcers (cure), in acne with hypertrichosis, in epithelioma and rodent ulcer, and in warts. They appear to be doubtful as to the value and application of the method for depilation in cases of hypertrichosis, owing to the difficulty of controlling the degree of reaction. Two cases of psoriasis received no benefit under the focus-tube exposure.

The exact agency of causation of focus-tube dermatitis is still uncertain. Various authorities attribute the process to ultra-violet rays, to the *x*-rays, or to electrical discharges connected with the focus tube. The matter, therefore, is still in doubt.

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* *Fortschritte auf dem Gebiete der Röntgenstrahlen*, Band iv., Heft 1, June, 1901.

The pathological changes in the skin have been investigated by Gassmann and Schenkel, and by Unna.* As might be expected, there is nothing specific in the inflammatory changes set up in this form of dermatitis. Unna concluded that the more resisting histological elements of the skin were involved in the process.

The time taken up in the treatment of patients can be materially shortened by running two or three tubes from the same coil and making several exposures simultaneously. The possibility of doing this has been demonstrated by Mr. H. W. Cox, who found that with a powerful coil and a Mackenzie Davidson break he had no difficulty in lighting up three focus tubes arranged in series. Should Röntgen-ray therapeutics attain a permanent footing in practical treatment, this saving of time is likely to be of no little value.

Dermatitis

M. le Clerc mentioned one case at the Lyons Medical Society in which an ulcer developed three weeks after exposure to the rays.

Focus-tube Dermatitis

At the Newcastle-upon-Tyne Clinical Society a case was shown by Dr. A. H. Hobbs.† A woman had been subjected to the rays six months previously for loose body in the joint. Sixteen days later the skin which had been most exposed to the rays developed an inflammatory condition, and in three to four weeks a well-marked bulla appeared. An ulcer, which was intractable to treatment, resulted, and was present when the patient was shown to the society. The slowness of development of the injury is remarkable.

Burns

Only two Röntgen ray burns were reported during the Spanish-American War:‡ one produced by a coil, and one by a static machine. In each case the exposures were long and frequently repeated, and the apparatus was not working at its maximum.

* *Fortschritte*, vol. ii., p. 128.

† *Lancet*, February 17, 1900, p. 466.

‡ Borden, 'Röntgen Ray in Spanish-American War.'

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